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March 11, 2005
Refer to: 911–05–003–ESB

TO: Distribution

FROM: Eugene S. Burke

SUBJECT: February 08, 2005 Resource Allocation Review Board (RARB) Meeting Minutes

The following are the Minutes of the NASA/JPL Deep Space Network (DSN) Resource Allocation Review Board (RARB) Meeting held at JPL on February 8, 2005. The purpose of this Review is to address the oversubscription of the DSN 26/34/70-meter tracking assets. The Review Board consists of Project Managers, Project Scientists, and key JPL Interplanetary Network Directorate (IND) Deep Space Mission System (DSMS) Managers or their representatives. The Board is responsible for reviewing new or changed requirements, adopting recommendations to reduce periods of heavy contention, and for controlling changes to requirements. This Review was tasked to address contention in 2006, 2007, and 2008.

Review Board Members

The following Review Board Members or their representatives were in attendance:

Rich Miller	JPL	Acting Chairman
Gene Burke	JPL	Resource Allocation Planning & Scheduling Office Manager
Al Bhanji	JPL	DSMS Development, Operations and Service Office Manager
Amir Behrozi	JPL	Dawn Project Representative
Eugene Brower	JPL	Mars Global Surveyor Representative
Candace Carlisle	GSFC	ST-5 Deputy Project Manager
Pat Carr	ITT	ITT JPL Program Manager
Jim Erickson	JPL	Mars Exploration Rover Project Manager
Chad Edwards	JPL	IND Mars Network Office Manager
Bob Farquhar	APL	MESSENGER, New Horizons Project Representative
Stephen Gunter	JPL	Kepler Project Representative
Jared Hall	JPL	Deep Impact Project Representative
Dwight Holmes	JPL	Rosetta Project Representative
Chris Jacobs	JPL	Reference Frame Calibration Project Representative
Robert Lock	JPL	Mars Reconnaissance Orbiter Project Representative
Ed Massey	JPL	Ulysses/Voyager Project Manager
Bob Mase	JPL	Mars 2001 Odyssey Project Representative
Bob Mitchell	JPL	Cassini Program Manager
Steve Ostro	JPL	GSSR Project Scientist
Bob Ryan	JPL	Stardust Project Representative
Rance Skidmore	GSFC	GOES Project Representative

Martin Slade	JPL	GSSR Project Manager
Bob Sodano	GSFC	Space Science Mission Operations Project Representative (SOHO, WIND, Polar, Geotail, Cluster II, ACE, Image, MAP, STEREO)
Tommy Thompson	JPL	NASA Venus Express, Lunar-A and Hayabusa Project Manager Mars Express – U.S. Project Science Manager
Robert Wilson	JPL	Spitzer Project Manager
Pam Wolken	ITT	Radio Astronomy & Advanced Tracking and Observational Techniques Representative
Greg Wright	MSFC	Chandra Project Representative

Review Materials

All supporting material presented in the RARB Booklet as well as the NASA Headquarters material distributed during the meeting can be found at http://rapweb.jpl.nasa.gov/rarb.html.

Agenda

1. Introduction ..... R. Miller for B. Weber
2. Overview, Contention Summary ..... G. Burke
   - Action Items from August 2004 RARB ..... D. Morris
3. NASA Headquarters – Science Mission Directorate ..... C. Holmes
4. DSN Scheduling Reengineering Status Review ..... R. Miller/R. Bartoo
5. JPL DSMS Development Operations and Services Office ..... W. Sible
6. New Or Modified Project Requirements
   - Venus Express ..... T. Thompson
   - ST-5 ..... C. Carlisle/B. Shendock
   - Reference Frame Calibration ..... C. Jacobs
7. Resource Contention
   - Analysis & Recommendations ..... N. Lacey
   - Responses ..... Projects
   - Discussion / Decisions ..... All
8. New Action Items & Summary ..... G. Burke

Introduction – R. Miller, Acting, RARB Chairman

R. Miller welcomed the Review Board and thanked the mission representatives for attending the RARB. He also stated that during the next year and a half, the activity level for the DSN would be high and compounded by major downtimes for upgrades to the 70 Meter and 34 HEF antennas.

Noted that a report would be presented to the Board on the progress to perform a system level design of the DSN Scheduling System in order to enable process changes.

Overview, Contention Summary – G. Burke

The focus of RARB was to review and resolve contention periods for January 2006 through December 2008. He stated that the RAPSO team has worked closely with the individual projects to clear all of the contention periods. RARB Survey Results conducted at the August 2004 RARB were presented.

- Demographics:
  - 37% of Attendance response: (90% Project Staff with 38% Non-JPL)
- Continue Semi-Annual Meeting?
  - 95% Agreed or Strongly Agreed
- Keep High Priority Event Contention at RARB and Push Smaller Changes to monthly JURAP meeting?
  - 90% Agreed or Strongly Agreed
- Similar Results with the August 2000 Survey

Given the survey response and the progress achieved at the last two RARB's (last August and today), RAPSO is recommending holding an annual meeting with semi-annual analysis. A quick survey was conducted regarding when would be the best month for an RARB Meeting. By a show of hands, the attendees selected February. The August 2005 RARB Meeting will be cancelled and the next meeting will be February 2006. An evaluation of the August 2005 RARB Process (without meeting) will be presented at the February 2006 RARB.

Proposed Changes to the DSN 2005 Implementation Downtimes Schedule were discussed.

August 2004 RARB Action Items Review – D. Morris

Reported that the three August Action Items were closed and presented the following summary:

- Action Item 1 regarded the high load on DSS-14 during July and August 2006. The Principle Scientist agreed with the updated recommendations.
- Action Item 2 regarded the high load during August and September 2006. The Mars Program Office will coordinate MRO, MGS, MEX and Odyssey support to optimize use of MSPA.
- Action Item 3 regarded the high load on the 70M subnet during December 2006. SOHO has clarified their 70M support requirements during this antenna keyhole event.

NASA Headquarters Perspective – Science Mission Directorate – C. Holmes

In his **Views from Washington** report, C. Holmes, of the Earth-Sun System Division, Science Mission Directorate, NASA Headquarters, reported on the Science Mission Directorate and listed the DSMS missions by Headquarters Science Theme as follows:

- Solar System
  - Mars, Cassini, Stardust, Messenger, Deep Impact, Rosetta, Hayabusa
  - More Mars, New Horizons, LRO, Dawn, Venus Express, SELENE, future Discovery and New Frontiers

- Universe
  - Chandra, WMAP, Spitzer, INTEGRAL, GP-B
  - Kepler, SIM, JWST, Con-X, TPF
- Sun-Earth System
  - Voyager, Ulysses, SOHO, ACE, Polar, IMAGE, Cluster, Wind, Geotail
  - Stereo, ST-5, Solar Probe, Sentinels, future MidEx

The suggested budget through 2010 was shown and he indicated that he did not have any additional information than that which is available to the public.

DSN Scheduling Reengineering Status Review – R. Miller

R. Miller indicated that the Operations Assessment Review recommendation prompted JPL to do a system level design of the DSN Scheduling System - which will enable process changes.

Conclusions from Value-Stream-Mapping and the RAP Working Group revealed the following: (1) Too labor intensive, too many meetings, and inadequate disjointed tools; (2) No silver bullet (directly applicable outside process or software); (3) No recommendation to depart from a collegial process; (4) Primary recommendation is better tools; and (5) Process changes suggested (beyond better tools).

Concept of Operation Service Scheduling Subsystem – R. Bartoo

R. Bartoo stated that during January, the Concept of Operations draft Document for the Scheduling Subsystem System was nearly 85% drafted, and is currently being edited by members of the user community and the DSN. When asked he said that this group was R. Herrera, K. Zamora, C. Chang and J. Breidenthal. The anticipated distribution date for review of the document is March 2005.

The system envisioned will: (1) be a web-based interactive system; (2) Support multiple simultaneous users; (3) Contain intuitive graphical user's interfaces and displays; and (4) Have only one Master Schedule Database accessible to all users.

The Next Steps will be to: (1) Perform alignment between the SSS Concept of Operations Document and the SSS Functional Requirements Document; (2) Update and release both if necessary; and (3) Conduct a Concept Review.

DSMS Development, Operations and Services Program Office (DDOSO) – W. Sible

The former Operations Office 930 and Engineering Office 940 have been integrated together to form Office 920. The four main offices are organized to provide a "cradle-to-grave" process flow. Additionally, there are two support groups – Development and Operations Engineering Staff. All offices have the following functions: Requirement analysis, low level requirements generation, development of trade-offs and cost estimating, selection of program work content in response to SE requirement, implementation and delivery, equipment operations and maintenance, monitoring of performance via DR (Discrepancy Report) analysis and mission feedback. The ITT (Prime DSN

Operations and Maintenance contractor) engineers are integrated into this structure.

Key Tasks to be completed in 2005:

- X/X/Ka-band feeds for BWG Antennas
  - DSS-34
- Antenna controllers for the 70m and 34m HEF
  - Will require significant downtime
- TTC UPL/DTT V5.5 & V5.7
- DSS-65 Relocation
- DSS-43 Hydrostatic Bearing Assembly (HBA) Task

Significant Operations Accomplishments from September 2004 through January 2005 include the extremely high quality support provided to Deep Impact Launch on January 12, 2005.

Significant Operations Plans through August 2005 include Cassini Encounters and Maneuvers, Rosetta EGA Closest Approach, Deep Impact Maneuvers, Impactor Release, Encounter & Playback, Messenger Maneuver & Earth Flyby, NOAA-N Launch, Stardust Maneuver, Voyager DTR Playback, GOES N Launch, and MRO Launch.

Venus Express Mission – T. Thompson

An overview of the Venus Express mission was presented. The ESA's Venus Express mission will revolutionize our understanding of the evolution of the Venusian's atmosphere; and satisfies many of the objectives identified in the Next Decadal Study. The mission's synergistic set of experiments measure key aspects of Venus encompassing: the surface, the middle and upper portions of the Venusian's atmosphere, and the interaction between the Venusian's atmosphere and the solar wind. The Venus Express mission is an important pathfinder for the Venus Sample Return mission. Venus Express is scheduled to launch October 26, 2005. The DSN is requested to support Launch and Orbit Insertion activities.

ST-5 Mission – C. Carlisle/ R. Shendock

An overview of the ST-5 mission requirements identified these key items:

1. Design, develop, integrate, test and operate three full service spacecraft, each with a mass less than 25kg, through the use of breakthrough technologies;
2. Demonstrate the ability to achieve accurate, research-quality scientific measurements utilizing a constellation of 3 nanosatellites, each with a mass less than 25-kg; and
3. Execute the design, development, test and operation of multiple spacecraft to act as a single constellation rather than as individual elements.

ST-5 launch timeframe is February 28 – March 31, 2006; launch site is Vandenberg AFB, Lompoc, CA; and the mission duration is 90 days.

Reference Frame Calibration – C. Jacobs

The importance of the DSN S/X and X/Ka Catalog Maintenance and Enhancement 24-hour requirements was discussed:

- DDOR Navigation
- Mars Ephemeris
- Calibrates: Earth Orientation and Station Locations
- Physical Models for upcoming DSN Array

It is anticipated that there will be future tracking requirements for 34 Meter BWG antennas using Ka-Band that will support increased spacecraft ephemeris accuracy.

After a spirited discussion with various projects/users representatives and numerous questions regarding impact to users if reduced support were garnered by RFC, an Action Item was proposed by C. Holmes, NASA Headquarters Representative.

Resource Contention Summary – N. Lacey

The changes since the August 2004 RARB were presented: Project Date Changes, Changes in DSN Resource Support, and the IND Resource Implementation Planning Matrix Changes. He also showed a graphic display of the DSN User / Mission Planning Set, and Major DSN Downtimes.

All Resource Analysis Team (RAT) Recommendations were accepted prior to today's meeting.

He noted that for source information regarding the complete "Red Book" click on the following URL: http://rapweb.jpl.nasa.gov/RARB-REDFeb2005.html

Summary – G. Burke

Burke thanked everyone for attending the meeting and announced that the next regular RARB meeting would convene February 14, 2006.

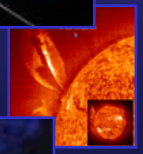
New Action Items

AI#	Year	Month(s)	System	Responsible	Due Date	Status
01	**2006-2008**	**All**	**RFC**	**B. Geldzahler**	**TBD**	**Open**

Action: Externally review the RFC requirements and implementations to understand impact to users.

deep space network

Resource Allocation Review Board



February 8, 2005

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AGENDA

February 8, 2005

• Introduction	B. Weber	8:30
• Overview, Contention Summary	G. Burke	8:40
– Action Item Status from August 2004 RARB	D. Morris	
• NASA Headquarters Perspective – Code S	C. Holmes	8:50
• DSN Scheduling Reengineering Status Review	R. Miller/R. Bartoo	9:10
• JPL DSMS Development Operations and Services Office	W. Sible	9:30
• New Or Modified Project Requirements		
– Venus Express	T. Thompson	10:00
– ST-5	B. Shendock	10:20
– Reference Frame Calibration	C. Jacobs	10:40
• Resource Contentions		
– Analysis & Recommendations	N. Lacey	11:00
– Responses	Projects	
– Discussion / Decisions	All	
• New Action Items & Summary	G. Burke	

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Review Board Members

Bill Weber	JPL	Chairman
Gene Burke	JPL	Resource Allocation Planning & Scheduling Office Manager
Claudia Alexander	JPL	Rosetta U.S. Project Manager
Al Bhanji	JPL	DSMS Development, Operations and Services Office
Pat Carr	ITT	ITT DSN O&M Program Manager
Chad Edwards	JPL	IND Mars Network Office Manager
Jim Erickson	JPL	Mars Exploration Rover (Spirit & Opportunity) Project Manager
Bob Farquhar	APL	MESSENGER, New Horizons Project Representative
Tom Fraschetti	JPL	Dawn Project Manager
Barry Goldstein	JPL	Phoenix Project Manager
Jim Graf	JPL	Mars Reconnaissance Orbiter Project Manager
Stephen Gunter	JPL	Kepler Project Representative
Chris Jacobs	JPL	Reference Frame Calibration Project Representative
Robert Lock	JPL	Mars Reconnaissance Orbiter Project Representative
Ron Mahmot	GSFC	Space Science Mission Operations Project Manager (ACE, Cluster II, Geotail, IMAGE, INTEGRAL, Polar, SOHO, WIND, WMAP)
Ed Massey	JPL	Ulysses/Voyager Project Manager
Rich Miller	JPL	DSMS Commitments Office Manager

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Review Board Members

Bob Mitchell	JPL	Cassini Program Manager
Dan Ossing	APL	STEREO Project Representative
Steve Ostro	JPL	GSSR Project Scientist
Jeff Plaut	JPL	2001 Mars Odyssey Mission Project Scientist
Bob Ryan	JPL	Stardust Project Representative
Bob Shendock	GSFC	ST-5 Project Representative
Rance Skidmore	Boeing	GOES Project Representative
Martin Slade	JPL	GSSR Project Manager
David Spencer	JPL	Deep Impact Project Representative
Tommy Thompson	JPL	Venus Express, Lunar-A and Hayabusa Project Manager, Mars Express Orbiter, U.S. Project Science Manager
Tom Thorpe	JPL	Mars Global Surveyor Project Manager
Phil Varghese	JPL	2001 Mars Odyssey Project Manager
Bob Wilson	JPL	Spitzer Space Telescope Project Manager
Pam Wolken	JPL	Radio Astronomy & Advanced Tracking and Observational Techniques Project Manager
Greg Wright	MSFC	Chandra Project Representative

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Overview

Contention Summary

E. S. Burke

JPL

Introduction

- Welcome To The Resource Allocation Review
  - Board was Established to Provide Control of Tracking Requests 26, 34, & 70-Meter Subnets
  - Recommend Resource Allocation and Assist in Capacity Planning
- Conflicts in 2006 Through 2008 Needing Resolution

Contention Resolution Process

- Contention Explanation
- Resource Analysis Team (RAT) Recommendations
- Project Response To Recommendations
- Review Board Discussions
- Review Board Decisions

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RAPSO – RARB Survey Results (August 10, 2004)

- Demographics:
  - 37% of Attendance response: 90% Project Staff 38% Non-JPL
- Continue Semi-Annual Meeting?
  - 95% Agreed or Strongly Agreed
    - "The RARB still serves as a single point of information for me on the DSN. I like it that way. I always know when I will be here and get an update on where we are with the DSN. This should continue."
- Keep High Priority Event Contention at RARB and Push Smaller Changes to monthly JURAP meeting?
  - 90% Agreed or Strongly Agreed
    - "RARB serves as a useful forcing function to solve problems before the meeting and that's a good thing."
    - "Continue open presentation and discussion of future critical events on missions as it affects the DSN."
- Similar Results in the August 2000 Survey

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RAPSO – RARB Process Change Vision

- Progress In the Last Two RARB's (August 2004 & Today) and Survey Results

- Annual Meeting With Semi-Annual Analysis
  - There Will Be One RARB Meeting
  - There Will Be Two RARB Analysis/Recommendations/Responses
  - Evaluate New RARB Process

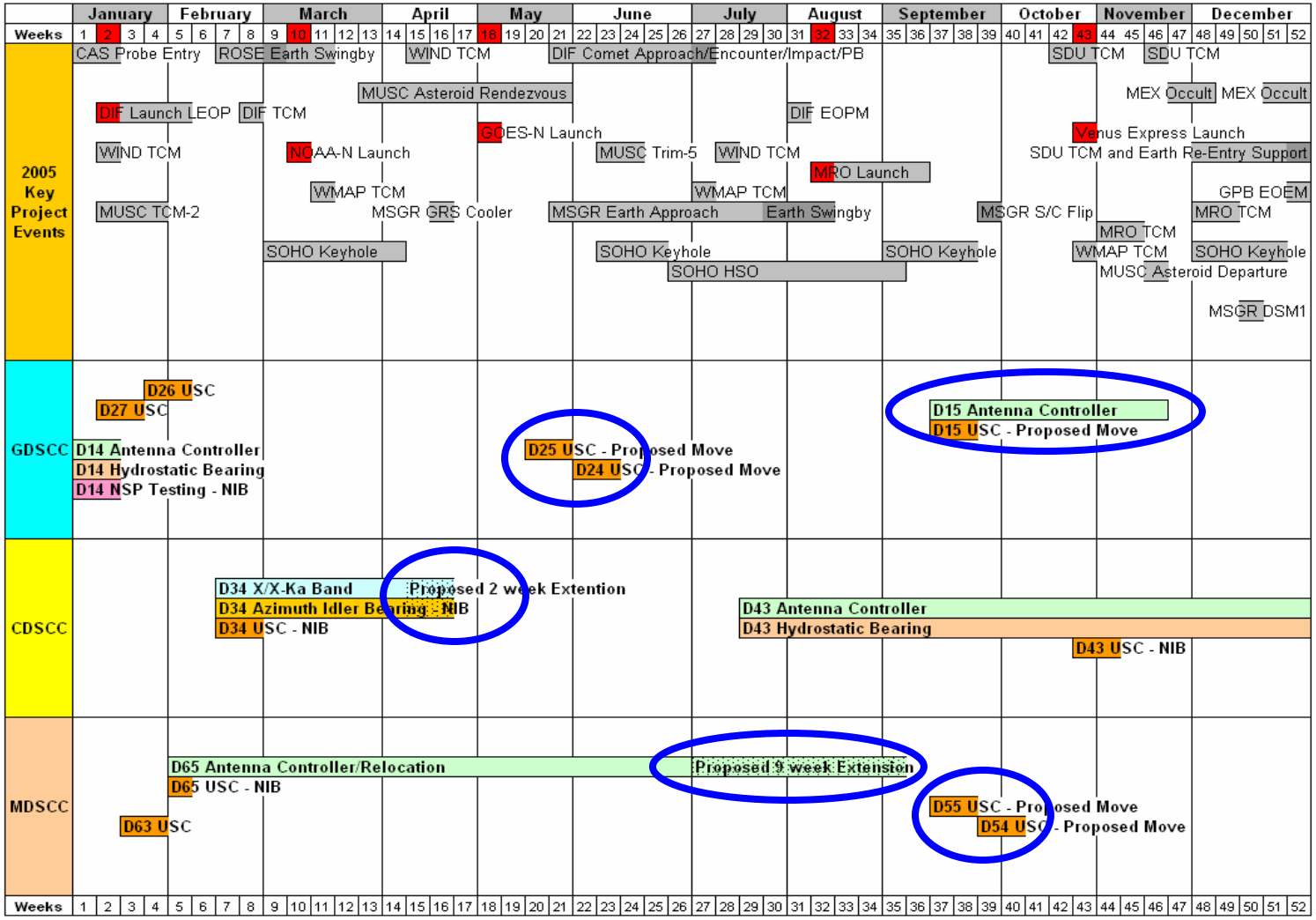
- Survey Today: When Is The Best Month For an RARB Meeting?
  - February or August?

  - If February, No Meeting This August

2005 Proposed Implementation (Downtime) Changes

- Delay Start of 34HEF Antenna Controller Replacement (ACR) To Mid-April
  - Extend DSS-65 ACR Downtime to End in Week 35 (August 31)
  - Move Microwave Subsystem Controller (USC) Downtime For:
    - DSS-55 From Week 29 – 30 to Week 37 – 38
    - DSS-54 From Week 35 – 36 to Week 39 – 40
- DSS-15 ACR Stays in September – November, 2005; Add USC to Downtime
  - Move Microwave Subsystem Controller (USC) Downtime For:
    - DSS-25 From weeks 22 – 23 to Week 20 – 21
    - DSS-24 From weeks 23 – 24 to Week 22 – 23
- Extend DSS-34 Two Weeks (End in Week 16) Ka-Band Blind Pointing Tests

Proposed Downtimes for 2005



Revised: February 2, 2005

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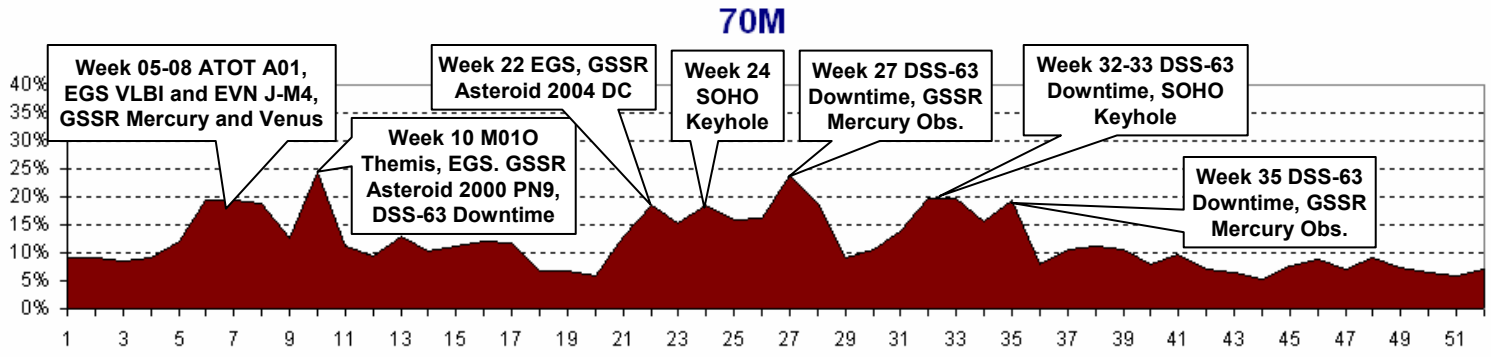
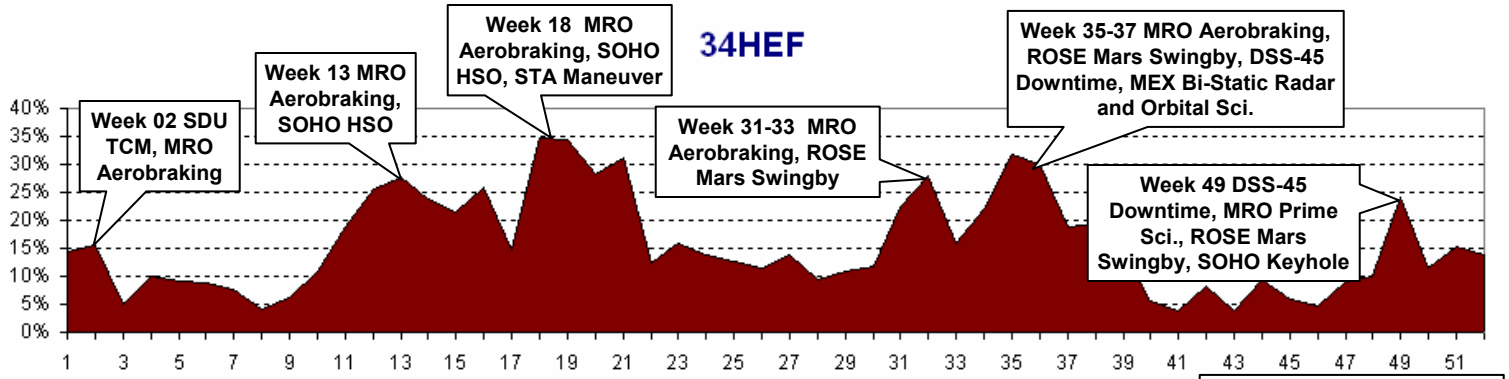
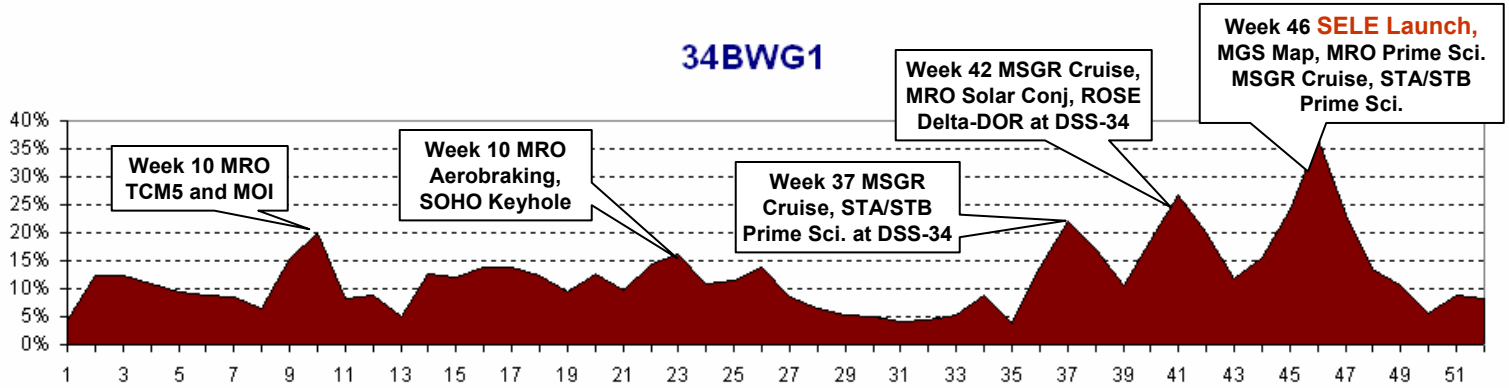
2006

Percent of Unsupportable Time by Subnet







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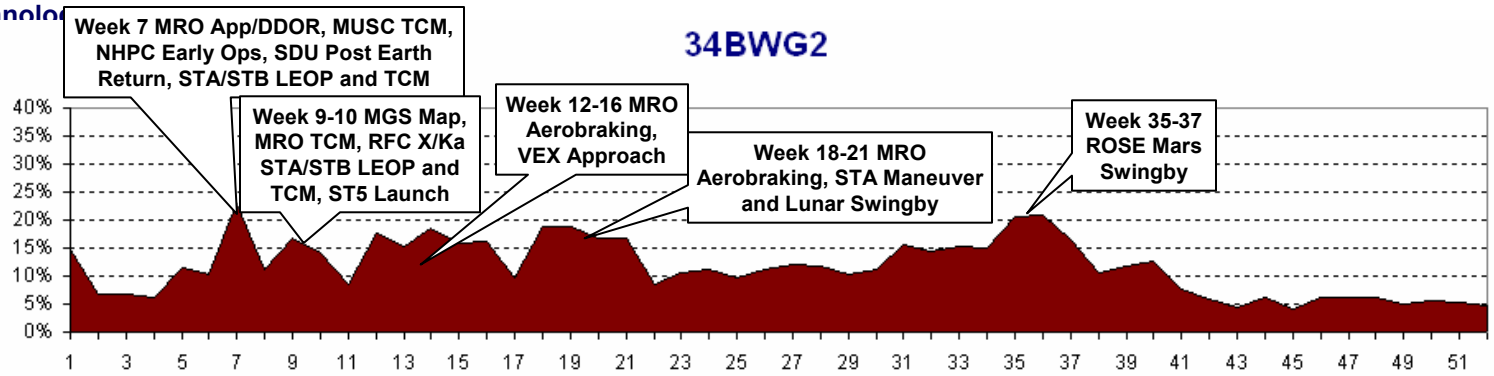
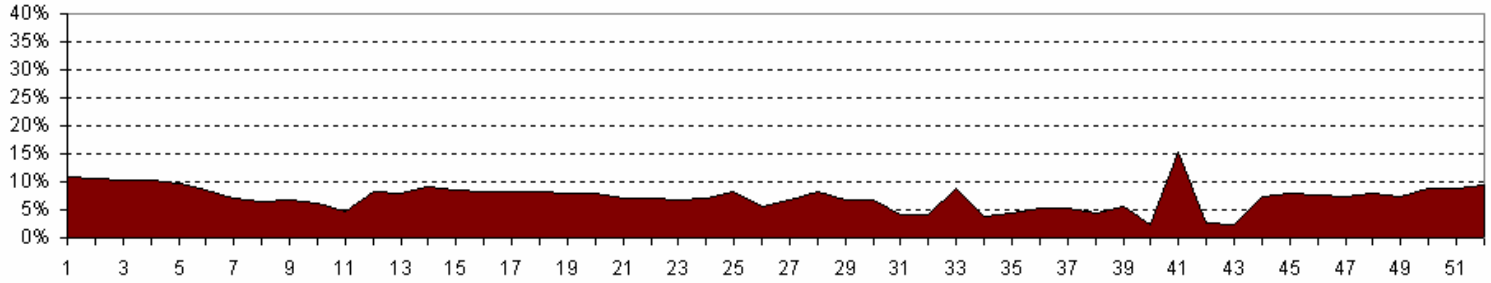
2006

Percent of Unsupportable Time by Subnet

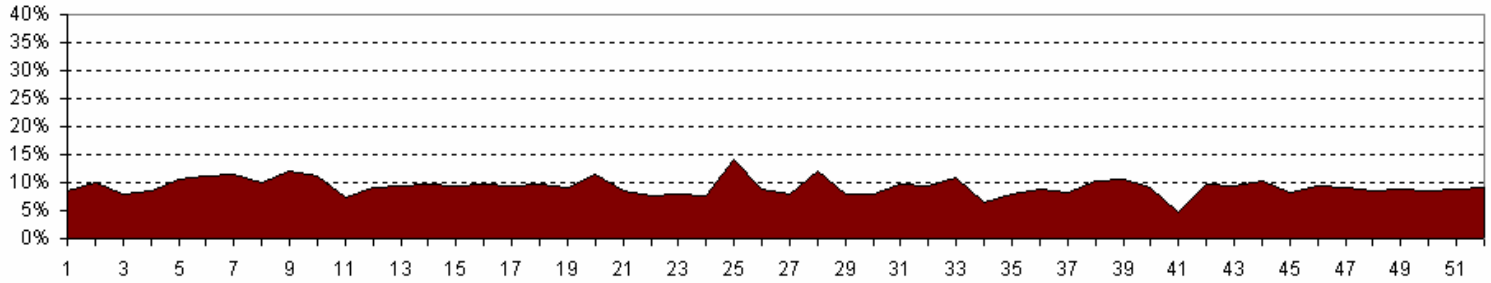
34BWG2



34HSB



26M



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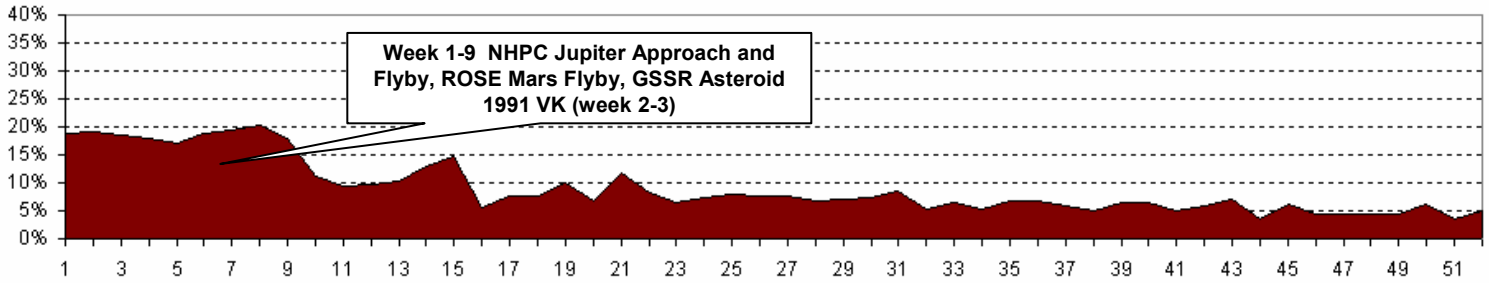
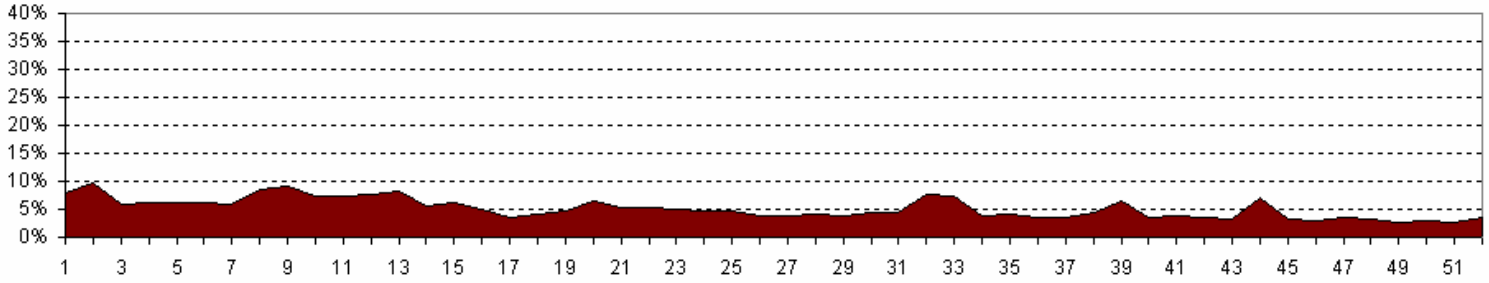
2007

Percent of Unsupportable Time by Subnet

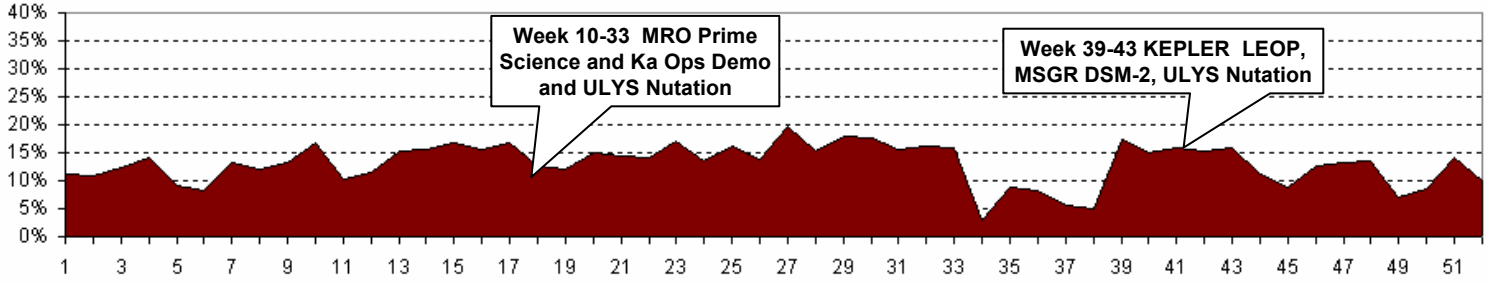
70M



34HEF



34BWG1



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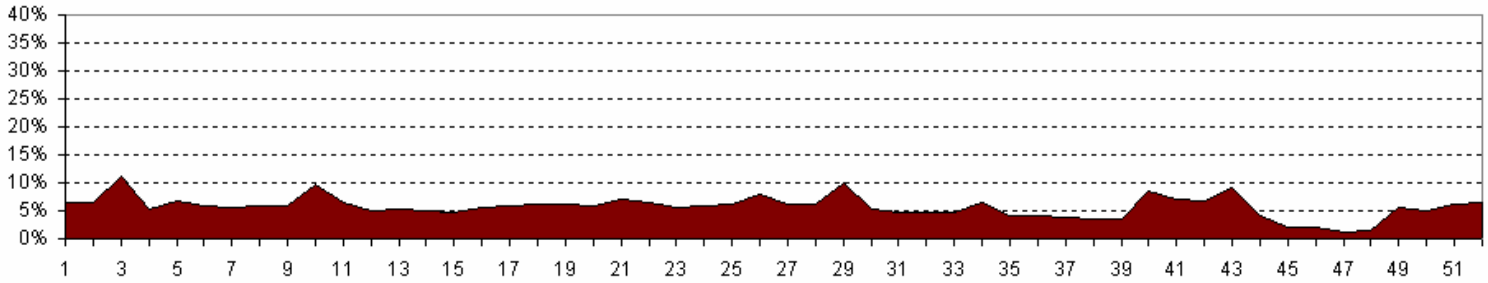
2007

Percent of Unsupportable Time by Subnet

34BWG2



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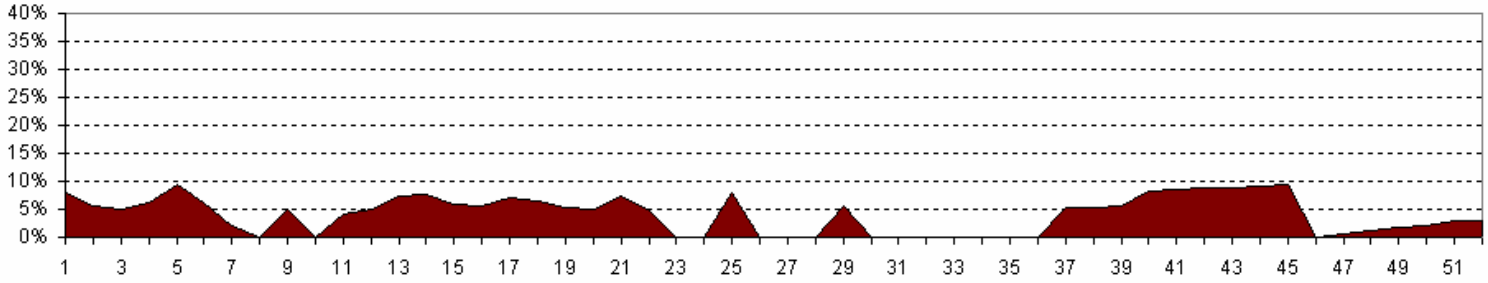
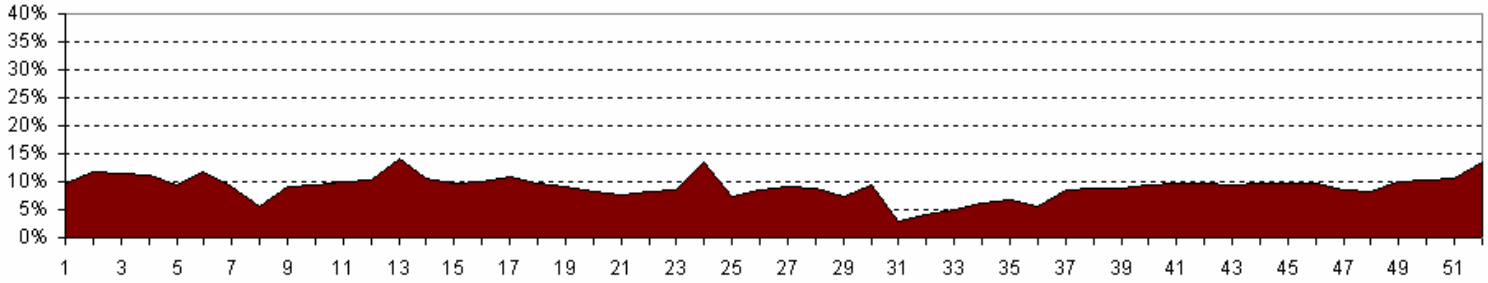


26M



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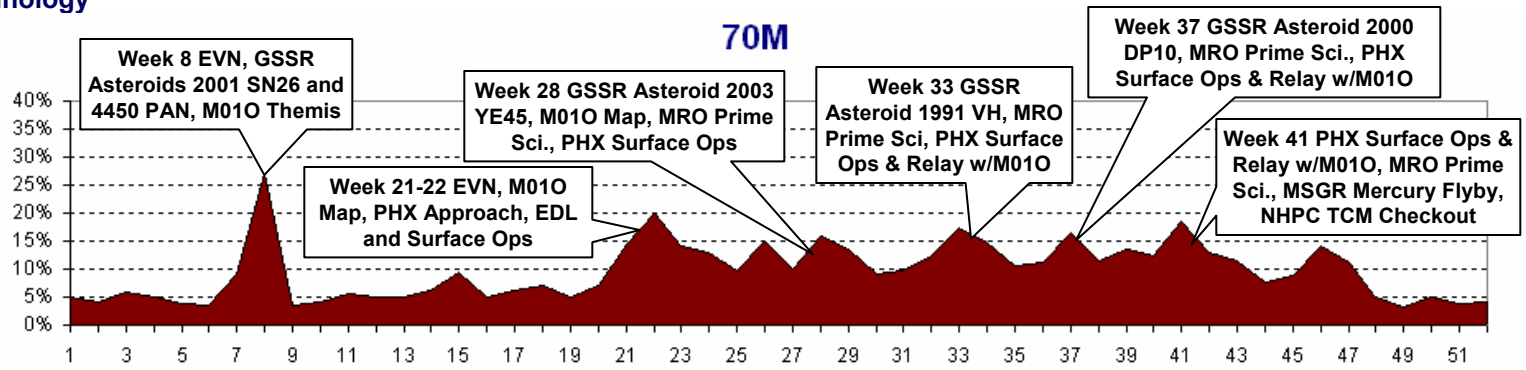
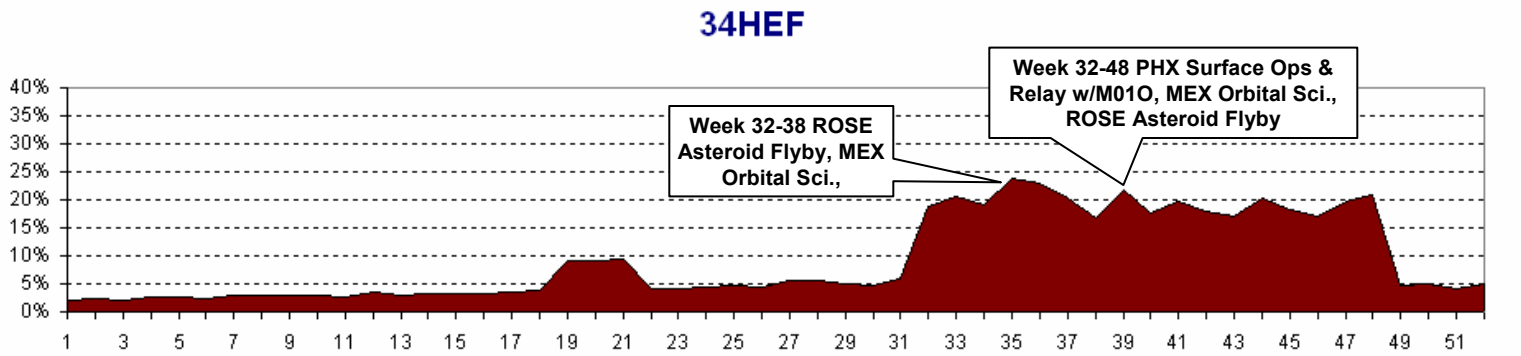
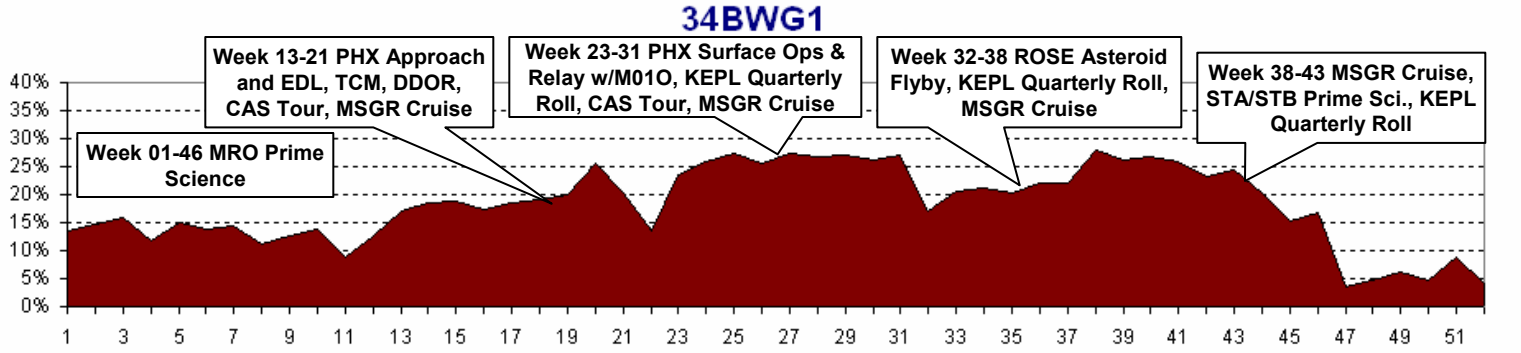
2008

Percent of Unsupportable Time by Subnet







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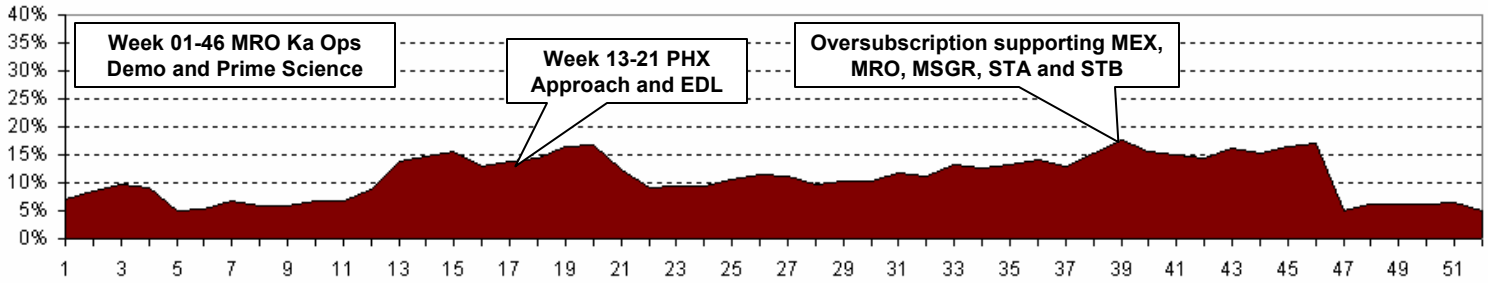
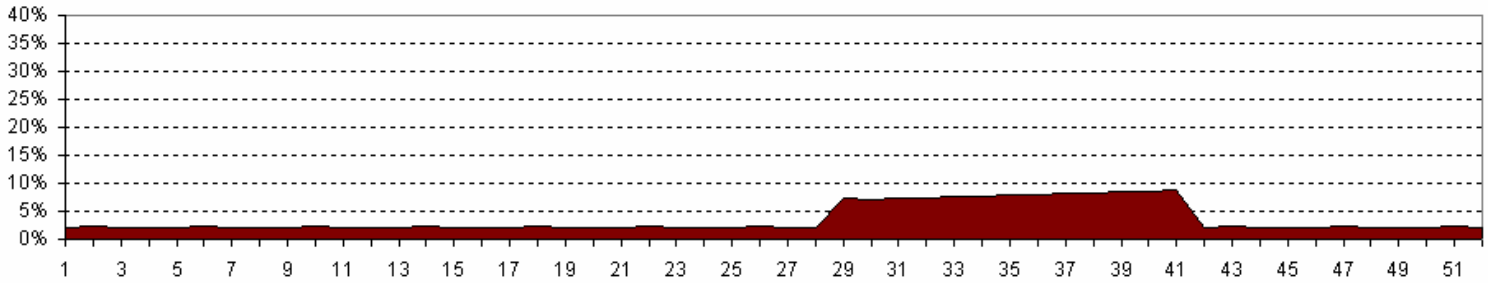
2008

Percent of Unsupportable Time by Subnet

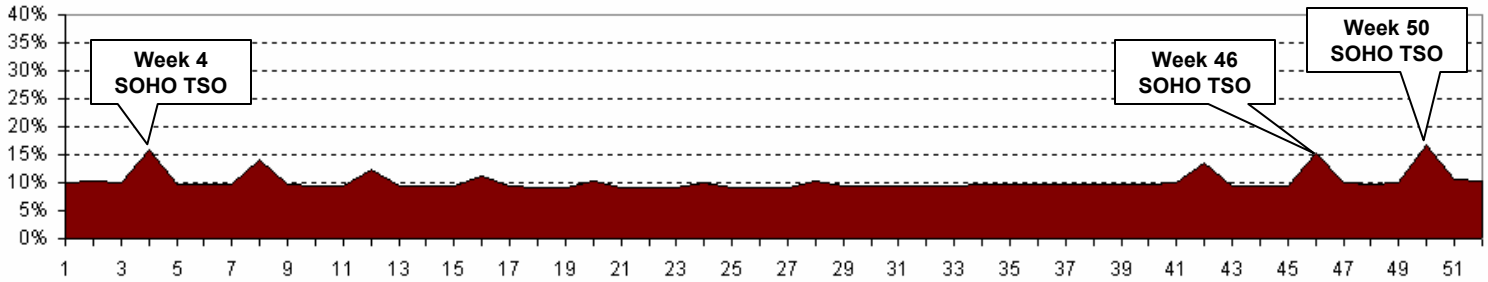
34BWG2



34HSB



26M



Reference Frame Calibrations

- RFC S/X CAT M&E 24-Hour DSS-15/45 and 24-Hour DSS-15/65 Baselines Supports
  - Scheduled on 6 Week Intervals – Saturday/Sunday GMT
  - Baselines are scheduled with maximum separation of 4 weeks
  - Weekend Supports will be negotiated during the Mid-Range Scheduling Process
  - If the DSS-15/45 baseline is not available use the following alternate plan:
    1. DSS-14/43 2. Any combination of 70M or 34HEF pairs
  - If the DSS-15/65 baseline is not available use the following alternate plan:
    1. DSS-14/63 2. Any combination of 70M or 34HEF pairs

- RFC X/Ka CAT M&E 24-Hour DSS-26/34 and 24-Hour DSS-26/55 Baselines Supports
  - Scheduled on 6 Week Intervals – Saturday/Sunday GMT
  - Baselines are scheduled with maximum separation of 4 weeks
  - Weekend Supports will be negotiated during the Mid-Range Scheduling Process
  - If DSS-26 is not available use DSS-25 or DSS-24 (after Ka-Band Install - 10/23/06)
  - If DSS-55 is not available use DSS-54 (after Ka-Band Install - 08/01/07)

A Note at the end of the Monthly Recommendation Page will Read:

RFC S/X CAT M&E or X/Ka CAT M&E 24-hour support is forecast for week XX. The following projects/users will be requested to accommodate the RFC CAT M&E requirement during the Mid-Range Scheduling Process: XXXX, XXXX and XXXX.

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Action Item Status From 10 August 2004 RARB

(Resource Allocation Review Board)

David G. Morris

JPL

Action Item Summary

AI#	*Year*	*Month(s)*	*System*	*Responsible*	*Due Date*	*Status*
01	2006	July-August	GSSR	M. Slade	12/17/2004	Closed

ACTION: Coordinate with Scientist representing Mercury Radar Speckle Displacement Co-observation with Green Bank Telescope or Arecibo Observatory on recommendations to minimize contention in these months.

RESPONSE: (9/16/2004) This action item was needed to reduce heavy contention for DSS-14, since Mars Missions, Cassini and Mercury are close together in the sky in July 2006. Prof. Margot is the PI for this observation.

(2/1/2005) The recommendation for July and August were revisited for this (February) RARB. The new July and August recommendations are now accepted. The Messenger Science Team support and recommend that these activities take place.

Action Item Summary

AI#	Year	Month(s)	System	Responsible	Due Date	Status
02	2006	August-September	Mars Missions	C. Edwards B. Mase K. Zamora	11/10/2004	Closed

ACTION: Coordinate MGS, Odyssey and MEX coverage during the MRO Aerobraking period.

RESPONSE: (10/22/2004) The Multi-Mission DSN Allocation Planning Team will provide an integrated schedule using MSPA when possible that will coordinate the needs of these four missions. This should reduce conflicts while satisfying their contact needs. Specifically, each Mars Mission responded as follows:

- MRO feels that it needs to reserve full commanding (U/L and D/L) during Aerobraking (Weeks 36-39) to ensure successful commanding of their large spacecraft command loads. MRO does not concur with RAPSO recommendations to MSPA.
- Mars Express (MEX) should be able to live with downlink only in September 2006.
  - Extra track per day for extra science data, should be no impact, particularly if done with MSPA.
  - One Bistatic radar proficiency track, may be affected as it requires an uplink. Should be proficient from a previous Bistatic Radar Campaign.
  - Solar Corona will be lost, but there are 9 weeks in this campaign, during solar conjunction.
- Odyssey (M01O) is willing to MSPA, when possible. Minimum requirements for commanding are Tuesday and Thursday.
- MGS is willing to MSPA, when possible.

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Action Item Summary

AI#	*Year*	*Month(s)*	*System*	*Responsible*	*Due Date*	*Status*
03	2006	December	SOHO	B. Dutilly	10/14/2004	Closed

ACTION: During Antenna Keyhole activities, the recommendation is to use 34m antennas versus 70m antennas due to oversubscription of the 70m subnet. 26m antenna usage was not in question.

RESPONSE: (8/26/2004) SOHO requires a minimum of four(4) hours of 70M coverage every 45 hours of gap time during a keyhole event. The purpose is to dump the SSR during that pass otherwise critical science data will be lost. We will continue to negotiate the time and resources needed in the mid range period for 70M support.

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Views from Washington

Chuck Holmes
Earth-Sun System Division
Science Mission Directorate
NASA HQ

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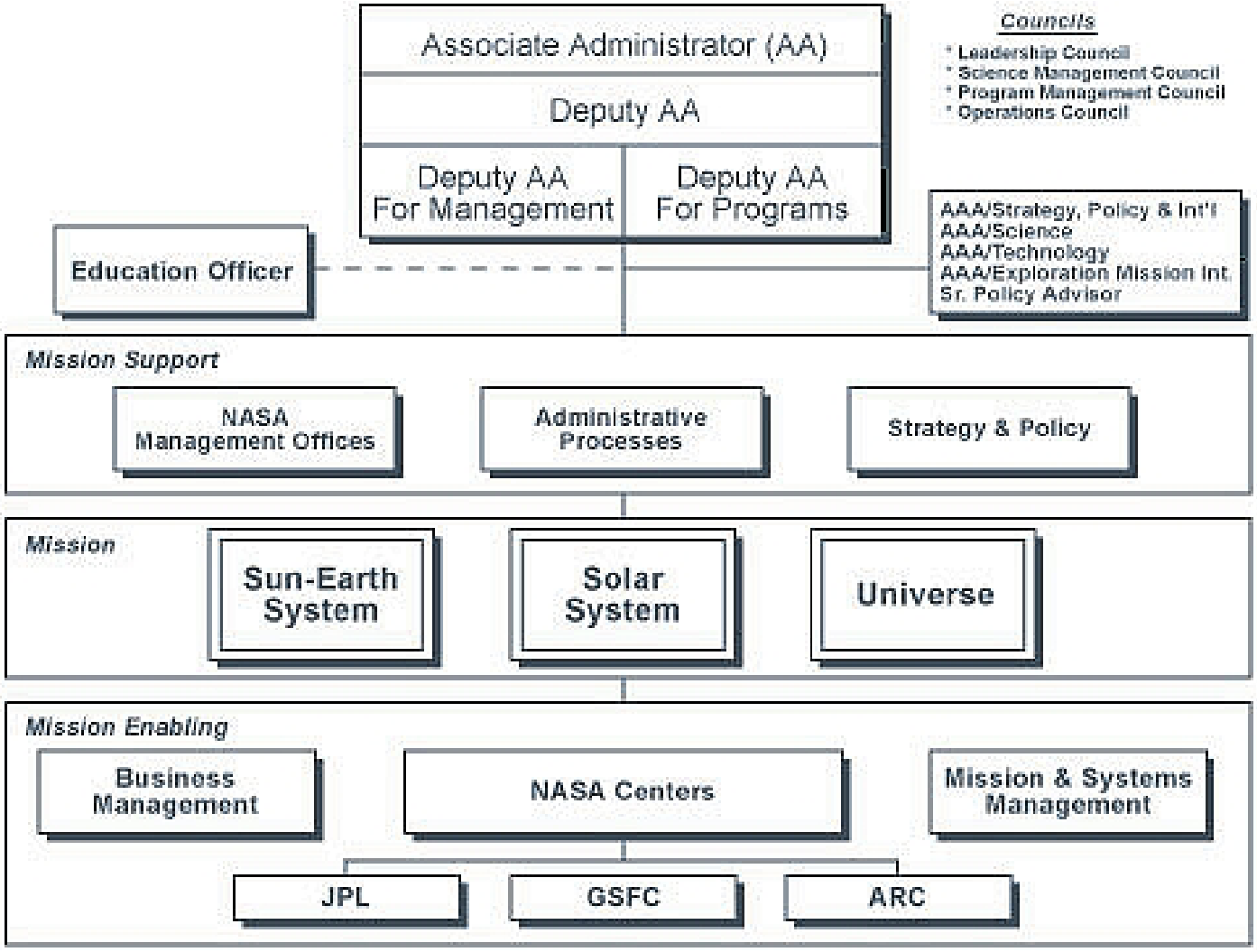
Science Mission Directorate



DSMS missions by HQ Science Theme

- Solar System
  - Mars, Cassini, Stardust, Messenger, Deep Impact, Rosetta, Hayabusa
  - More Mars, New Horizons, LRO, Dawn, Venus Express, Selene, future Discovery and New Frontiers
- Universe
  - Chandra, WMAP, Spitzer, INTEGRAL, GP-B
  - Kepler, SIM, JWST, Con-X, TPF
- Sun-Earth System
  - Voyager, Ulysses, SoHO, ACE, Polar, IMAGE, Cluster, Wind, Geotail
  - Stereo, ST-5, Solar Probe, Sentinels, future MidEX

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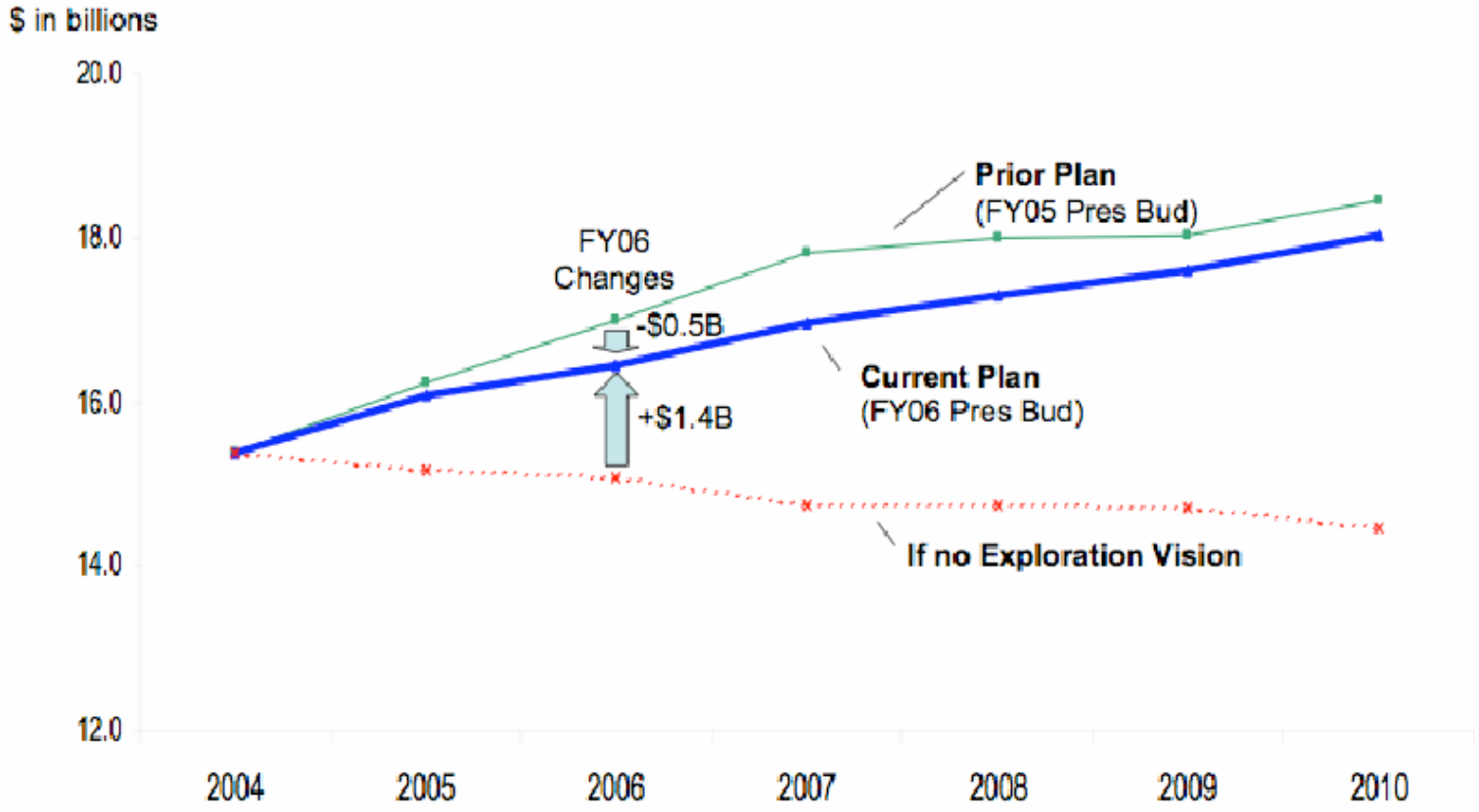
The Vision Remains an Administration Priority in a Challenging Budget Environment …



The Exploration Vision has enabled an increasing budget for NASA, although prior plans have been reduced in the government-wide effort to reduce deficit

($ in millions)	2005 *	2006	2007	2008	2009	2010
Science, Aero & Exploration	**8,912**	**9,661**	**10,550**	**11,215**	**12,210**	**12,796**
Science	5,364	5,476	5,960	6,503	6,853	6,798
Exploration Systems	2,568	3,165	3,707	3,826	4,474	5,125
Aeronautics Research	813	852	728	731	728	718
Education	166	167	155	155	155	155
Exploration Capabilities	**6,704**	**6,763**	**6,379**	**6,057**	**5,367**	**5,194**
Space Operations	6,704	6,763	6,379	6,057	5,367	5,194
Inspector General	**27**	**32**	**34**	**35**	**35**	**37**
Unrequested Items	426					
TOTAL	**16,070**	**16,456**	**16,962**	**17,306**	**17,612**	**18,027**
-- annual increases		2.4%	3.1%	2.0%	1.8%	2.4%
Emergency Hurricane Supplemental	126					

* - FY 2005 budget is shown in new budget structure for comparison purposes, and allocation by Mission Directorate does not include $426m in unrequested items to allow a direct comparison of content included in the President's request.

($ in Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010
SCIENCE	**5,476**	**5,960**	**6,503**	**6,853**	**6,798**
Solar System Exploration	1,900	2,348	2,832	2,999	3,066
The Universe	1,512	1,532	1,539	1,495	1,407
Earth-Sun System	2,064	2,081	2,132	2,359	2,325

The FY06 budget request for Science Mission Directorate includes:

- FY06 budget will support 55 missions in orbit, 26 in development, and 34 in design phase
- $858m, a 17% increase, for Mars/Lunar robotic exploration
- $372m, a 19% increase, to maintain Webb telescope on pace for 2011 launch
- $93m in development funds for Hubble to extend scientific productivity and initiate a robotic mission to safely deorbit the telescope
- $218m, a 17% increase, to maintain competitive efforts for Explorer Program
- $56m, a 33% increase, for Beyond Einstein program to study the universe
- $234m, a 16% increase, for studying the sun in Living With a Star
- $136m, a 26% increase, for competitive opportunities in Earth System Science Pathfinder
- $6.8b, a 23% increase in the projected annual budget by 2010, increasing the Science portion of total Agency budget from 33% in FY 2006 to 38% in 2010

DSMS activities at HQ

- Barry Geldzahler is returning from an 'introductory' site visit to South Africa as a possible location for a DSN array
- DSMS strategic planning has produced a roadmap
  - Being incorporated into the science theme roadmapping

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DSN Scheduling Reengineering Status Report

For the 8 Feb 2005 RARB

Rich Miller and Roger Bartoo

Operations Assessment Review

- The Operations Assessment Review recommendation:
  - "The [DSN] scheduling system should be automated because it is far too labor intensive. JPL needs to examine other systems to see how they have automated scheduling. We recommend the formation of a tiger team, to include outside experts, to address this issue and to help develop an evolutionary approach given present cost limitations."

- Has lead to an activity to do a system level design of the DSN Scheduling System which will enable process changes

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Conclusions from Value-Stream-Mapping and RAP Working Group

- Too labor intensive, too many meetings, and inadequate disjoint tools
- No silver bullet (directly applicable outside process or software)
- No recommendation to depart from a collegial process
- Primary recommendation is better tools
  - Look at entire system while considering new future needs
- Process changes suggested (beyond better tools):
  - Continuous process rather than batch conflict resolution
  - Customers working conflicts in front of submission to central process
  - Conflict free over whole horizon (Long range, mid range, and scheduling)

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Teams Memberships

Value-Stream-Mapping ('02)

John Milligan (CSOC); Roger Bartoo (JPL) Team Leaders
Randy Herrera Project Sequencing
Joe Guinn Project Navigation
Jim Frautnick Project Mission Planning
Belinda Arroyo Project Scheduling
Cynthia Abramo ISTP Project Scheduling
Ernestine Hampton Long-term and Mid-term Scheduling
Donna Dillard Short-term Scheduling
Deirdre Terry NOCC
Kim Massey DSN Complex
Art Landon NOPE/MSE/TMS Manager
Shan Malhotra, JPL System Engineer

DSN Scheduling User Group (DSUG)

Cynthia Abramo
Belinda Arroyo
Donna Dillard
Chad Edwards (chair)
Jan Ludwinski
Margaret Medina
David Morris
Kathya Zamora

Rap Working Group ('03-4)

Belinda Arroyo, Project Scheduling / 368 / 312
Roger Bartoo, RAPSO / 368
Chet Borden, RAPSO / 311
Jay Breidenthal, DSMS Systems Engineering / 905
Gene Burke, RAPSO / 930
Brad Clement, DSMS Technology / 367
Frank Donivan, Aerospace
Richard Doyle, IT Program Office / 980 (Chair)
Randy Herrera, Project Scheduling (Cassini) / 314
Allen Levine, GSFC
Shan Malhotra, SPS, Monitor and Control / 940 / 369
David Morris, RAPSO / 930
Steve Schaffer, DSMS Technology / 367
Jack Wallick, ITT
Yeou-Fang Wang, RAPSO / 311
Jay Wyatt, DSMS IT Program / 983 (Co-Chair)

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Concept Of Operation Service Scheduling Subsystem

Roger Bartoo

JPL

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Status – Where Are We?

- In early January, a Functional Requirements Document (FRD) for the SSS was reviewed by the DSN Scheduling Users Group
- On January 28, 2005, a 'Peer-review' was held on the FRD and updates and changes were suggested
- On February 2, 2005, the final of the SSS FRD version 1 was released for signature
- During January, the Concept of Operations Document for the SSS was nearly completely drafted, and is currently being edited by members of the user community and DSN. The document is ~85% complete.
- Expected distribution date for review of the SSS Concept of Operations Document is March 1, 2005

Briefly, What Is The Operations Concept For This New Tool?

- The system envisioned will:
  - Be an on-line, web-based interactive system;
  - Support multiple simultaneous users;
  - Contain intuitive graphical user interfaces and displays;
  - And have only one Master Schedule Database accessible to all users.

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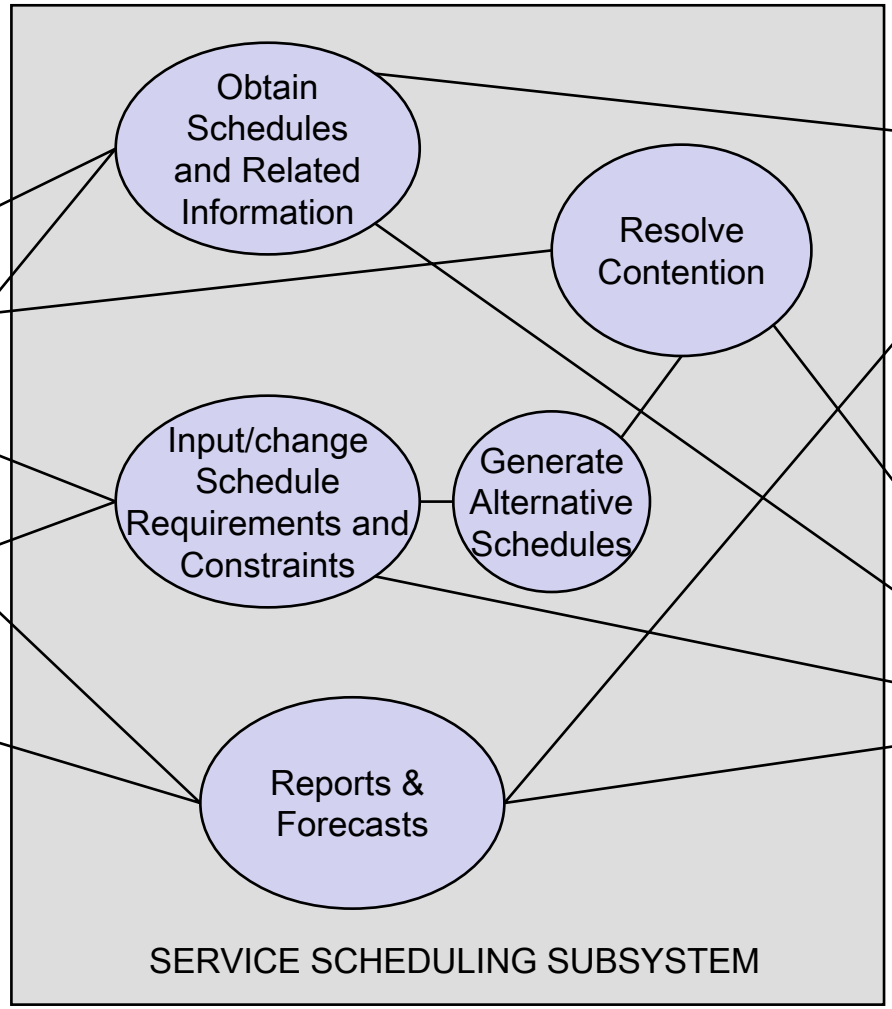
How Will It Be Used? - Uses of the Scheduling System

Tactical uses:
- Scheduling
- DSN Scientific
- DSN Maintenance
- DSMS Development
- Other DSMS Systems
- Mission Design
- Mission Sequencing



Performance Uses:
- DSMS Operations
- Mission Sequencing
- Other DSMS Systems

Strategic Uses:
- Mission Design
- DSMS Management
- DSMS Development
- DSMS Resource Analysis
- Scheduling
- Mission Sequencing

Management Uses:
- JPL & DSCC Operations
- Project Management
- DSMS Management
- Sponsor

How Will It Do This? - System Functions

- There are six system functions envisioned:
  - A Conflict-aware Scheduling Function
  - A Data Entry & Management Function
  - Scheduling Database(s)
  - A Conflict Resolution Function
  - A Conferencing or Collaboration Function
  - Data Reporting Function

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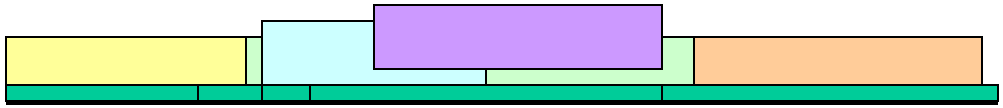
Conflict-Aware Scheduling - Concepts

Conflict-free Schedule



Conflict-aware Schedule

- Retains conflicts for negotiation
- Minimize conflicts
  - There are guidelines [rules] for generating a conflict-free aware schedule
  - There are mechanisms for retaining information on the conflicts
  - They should be visible to all users
- Support iterative negotiation to generate a conflict-free schedule

Conflict-Aware Scheduling - Concepts

- How can this be done? In two words: Requirement Attributes
  - Each Tracking Requirement Has Five Attributes:
    - Requirement (e.g., two 8-hour passes per week, etc.)
    - Constraints (e.g., View Periods, acceptable antennas, etc.)
    - Preferences (e.g., I prefer DSS-25, though any 34-meter will do)
    - Permissions (e.g., Though I want an 8-hour pass, I will accept a reduction to 6-hours in the case of conflict)
    - Fixed ('locked-down') or Flexible Requirement (i.e., some tracks are 'must haves' at the scheduled time and are not to be moved, others can be moved to anytime in the week subject to constraints & permissions)
  - Any mission scheduled is perceived to have a mix of both fixed requirements and flexible requirements
  - And, straight forward scheduling rules related to 'Prime' Missions and 'Extended' Missions should suffice to do a large part of the scheduling problem

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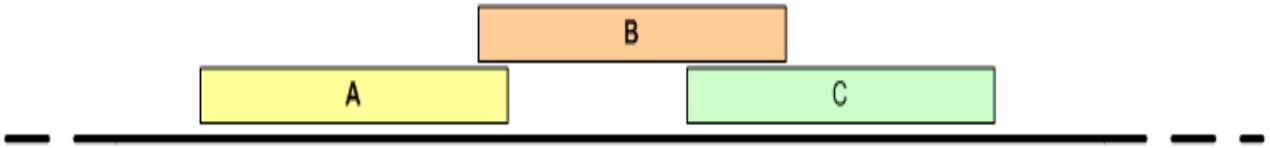
Conflict-Aware Scheduling - Concepts

- For example, assume the following conflicted scheduling problem:



The dark line represents the asset over time. Mission A is a prime mission and missions B and C are extended missions. All three are in conflict.

- Each have requested 8-hour passes but with all given permissions to be reduced to 6-hours in the event of conflict. The rule suggested for this case is:
  1. First attempt to reschedule B to another asset, then C and last A. If in doing so a new conflict arises at each step, then return and try the next mission provided their requirements and permissions allow it.
  2. Next if step 1 did not resolve the conflict, reduce B and C equally to their permission limits or until B fits.
  3. If B still does not fit, then reduce A until B fits to the limit allowed by A's permissions.
  4. If the conflict persists, retain the original conflict an e-notify subscribers.
- Write the conflict to the 'Conflicts' Database

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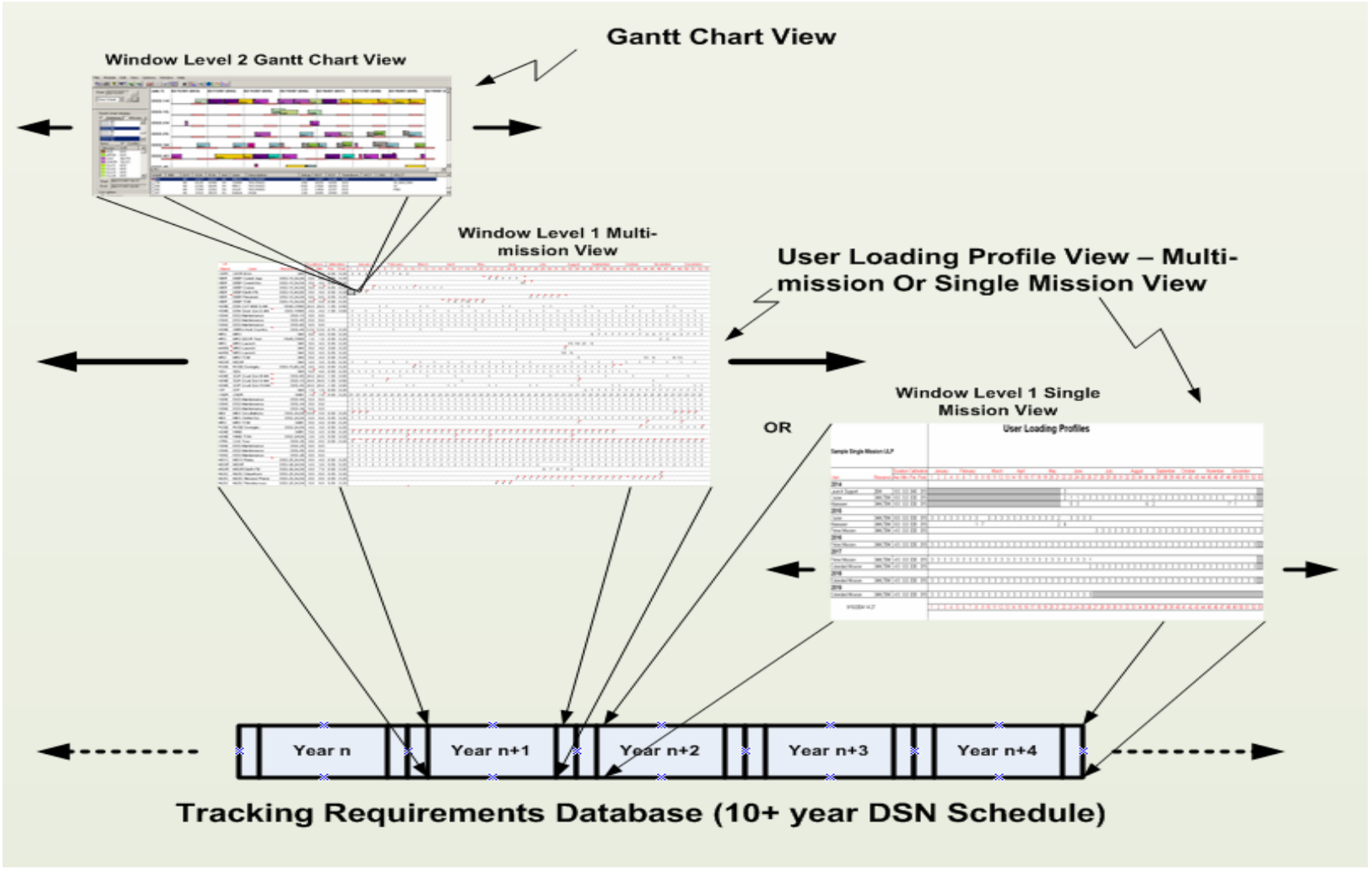
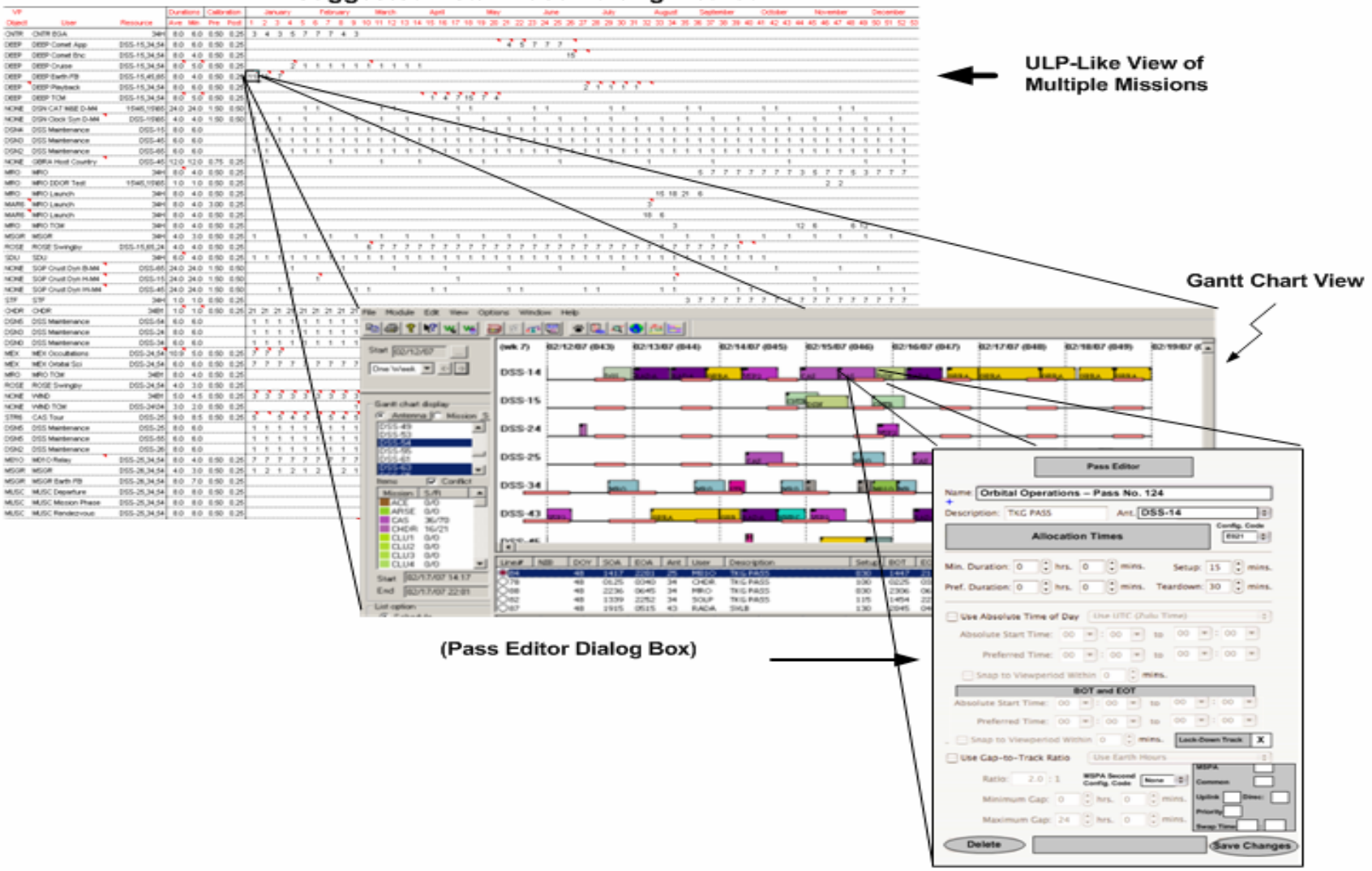
Data Entry & Management Function – Concept Views

- Consider the following concept for accessing, viewing or editing schedules:



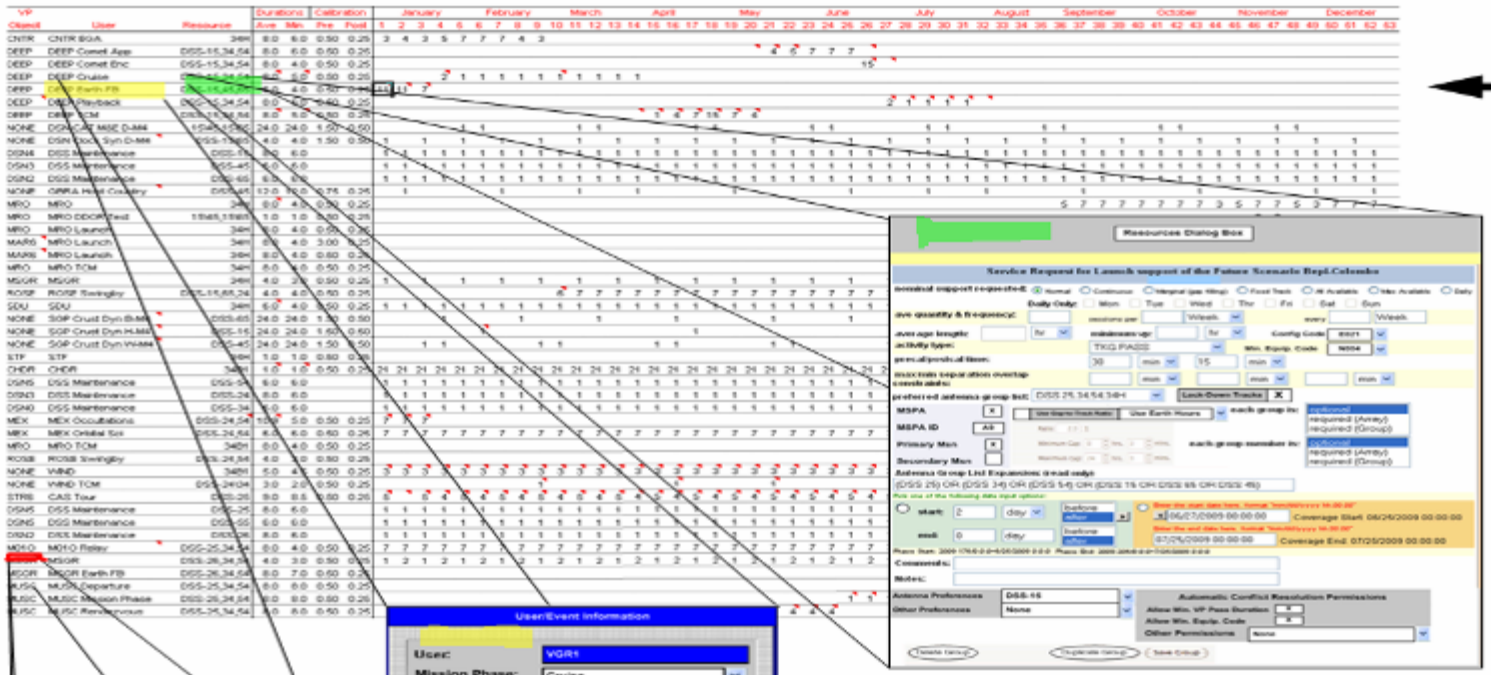
Data Entry & Management Function – Concept Views

Suggested Detail Pass Editing Method



Data Entry & Management Function – Concept Views

Desired Database High-level Input & Editing



ULP-Like View of Multiple Missions

RESOURCES Input Pull-down Menu Or Dialog Selection Box

(Pull-down Menus or Dialog Selection Boxes)

USER/EVENT Input Pull-down Menu Or Dialog Selection Box

View Period Pull-down

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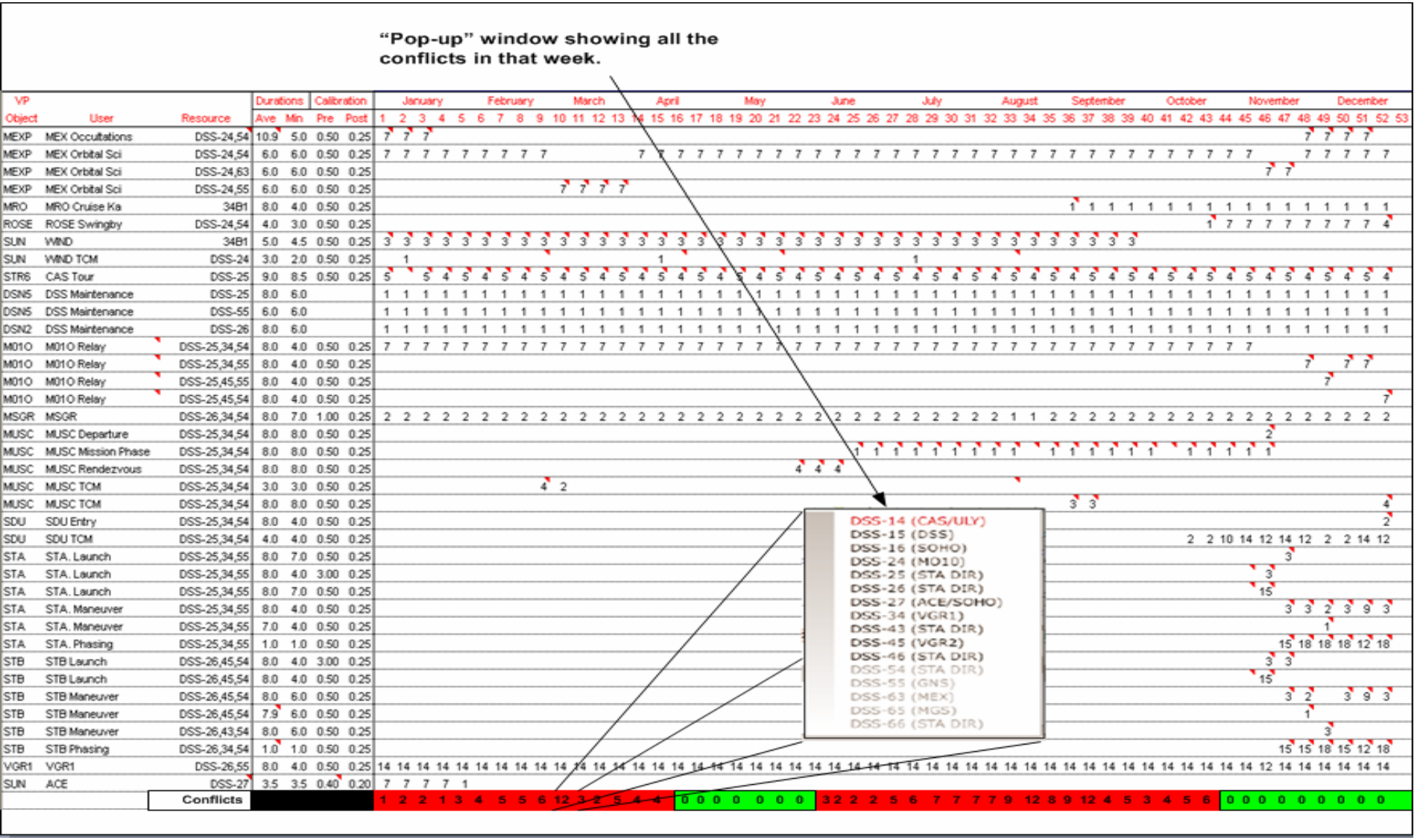
Data Entry & Management Function – Concept Views



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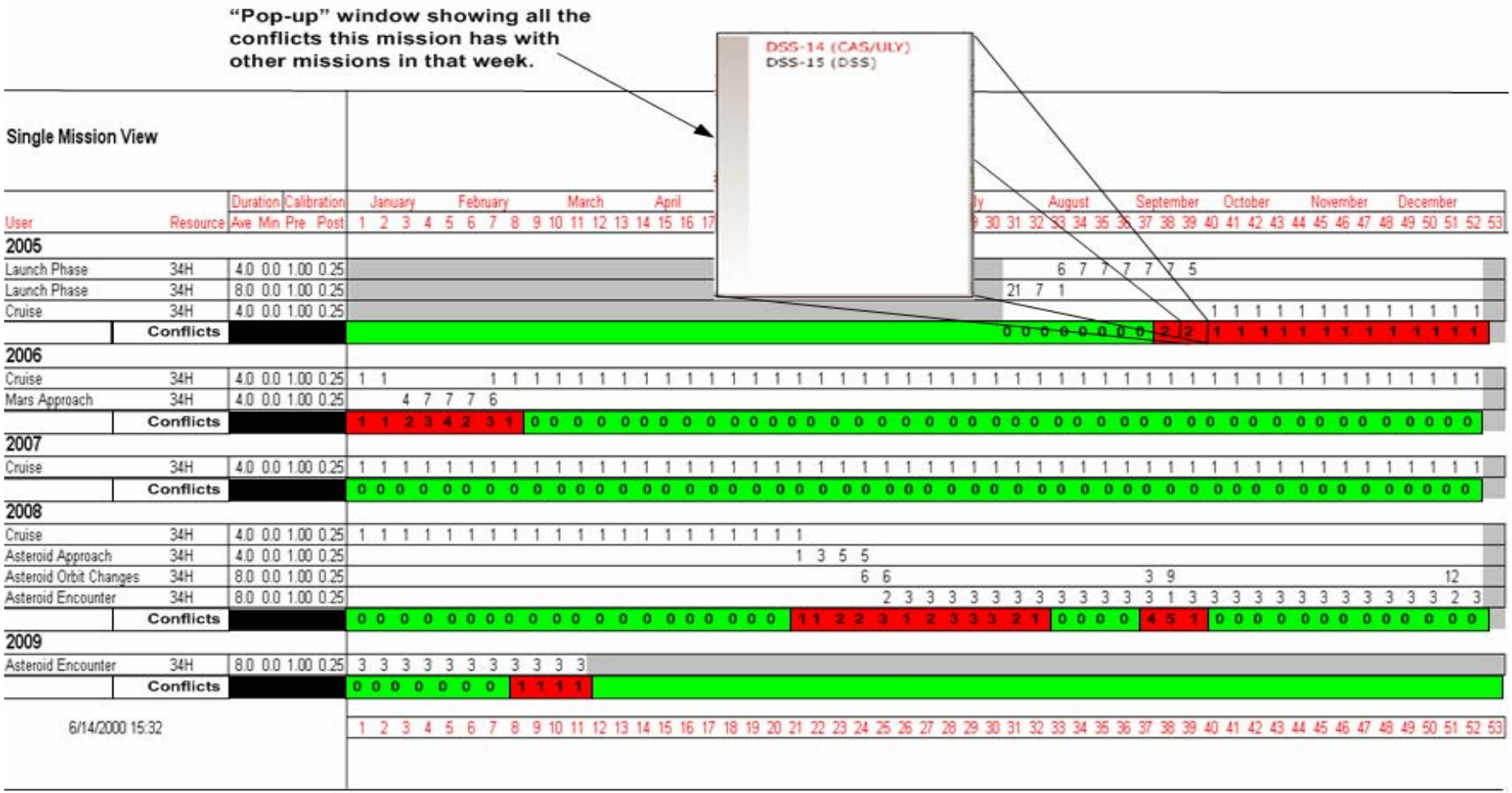
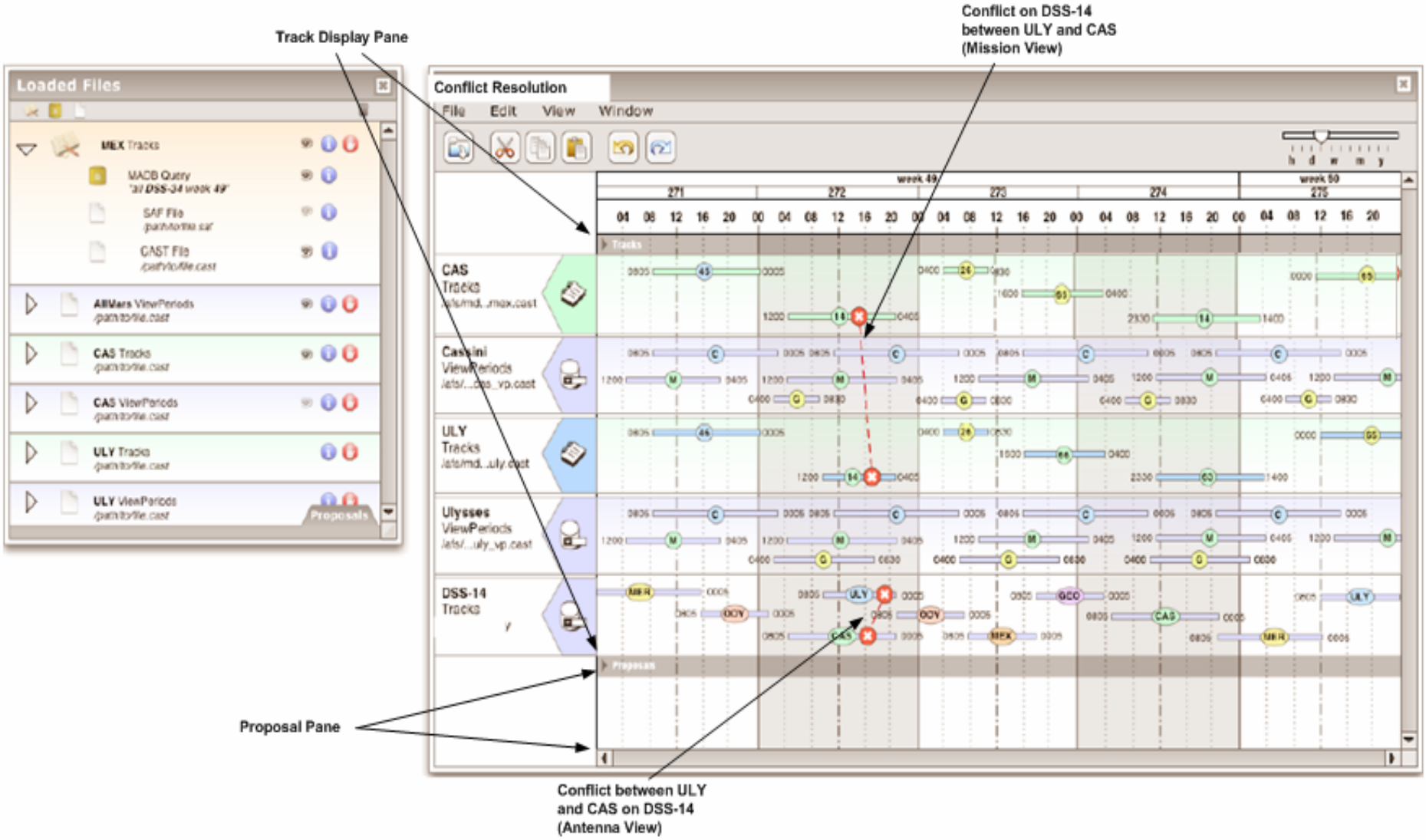
Data Entry & Management Function – Concept Views



Conflict Resolution – Concept Views



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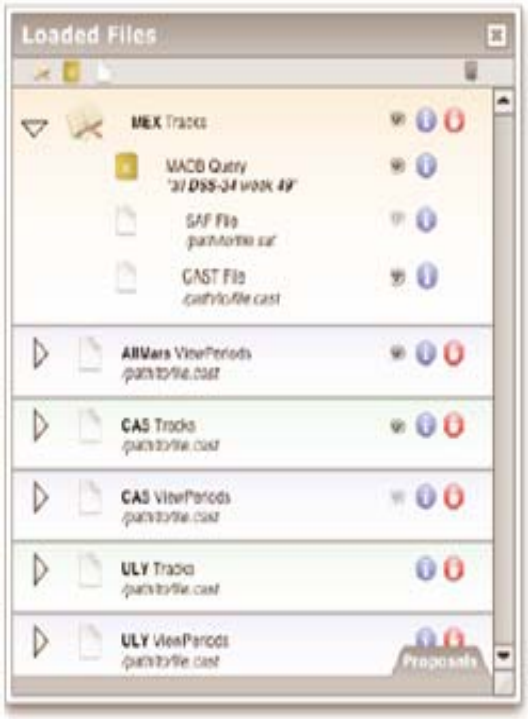
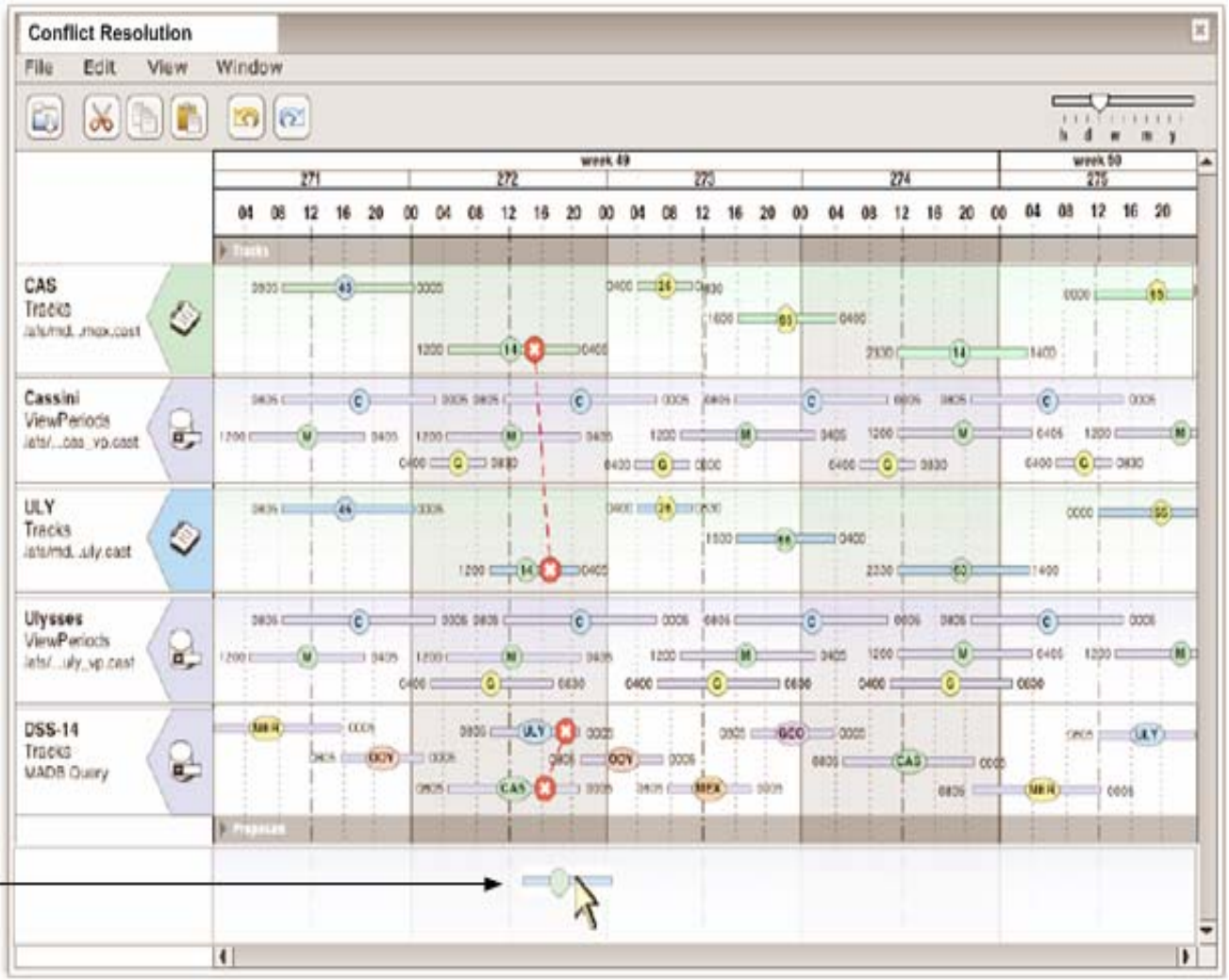
Conflict Resolution – Concept Views





The User Drops the Conflicted Track in the Proposal Area

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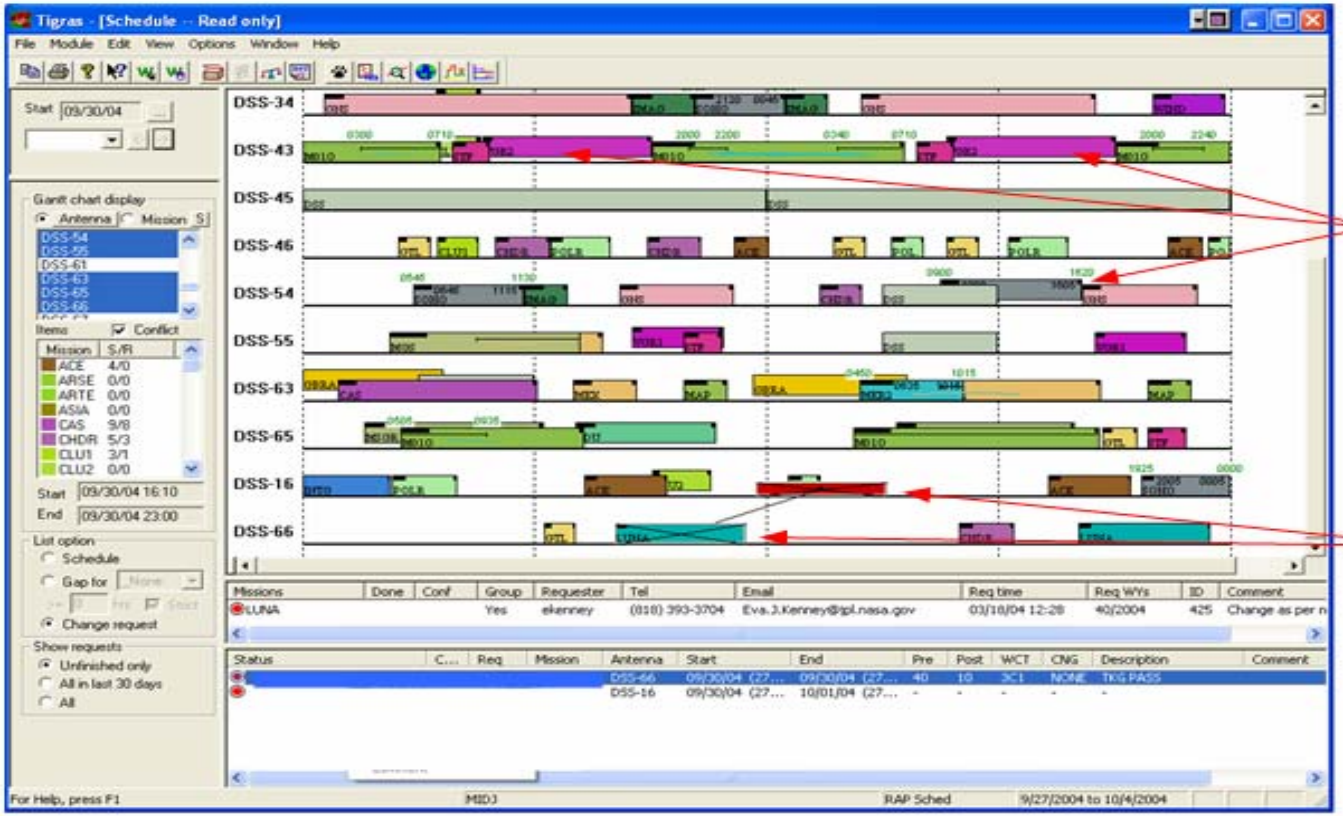
Conflict Resolution – Concept Views



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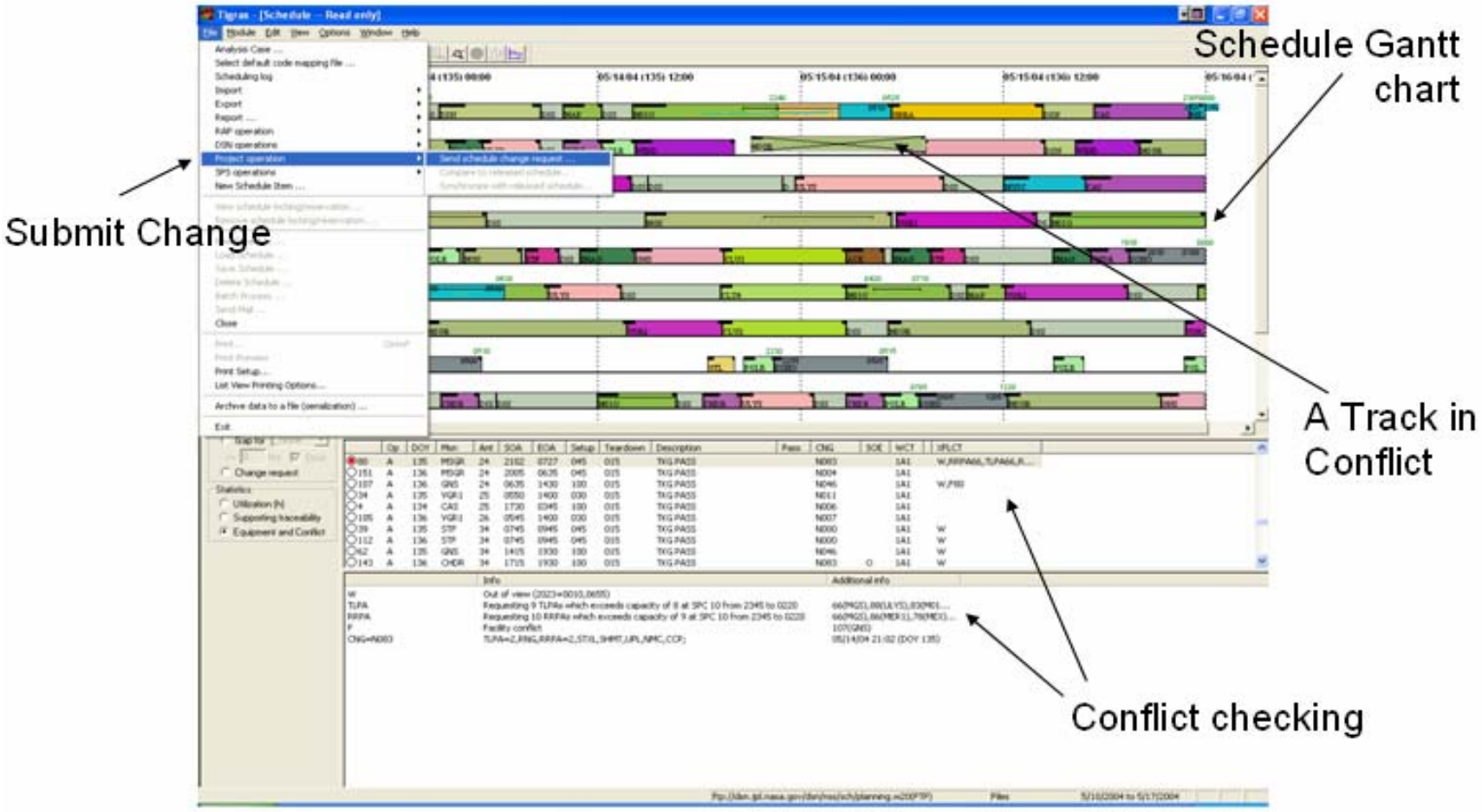
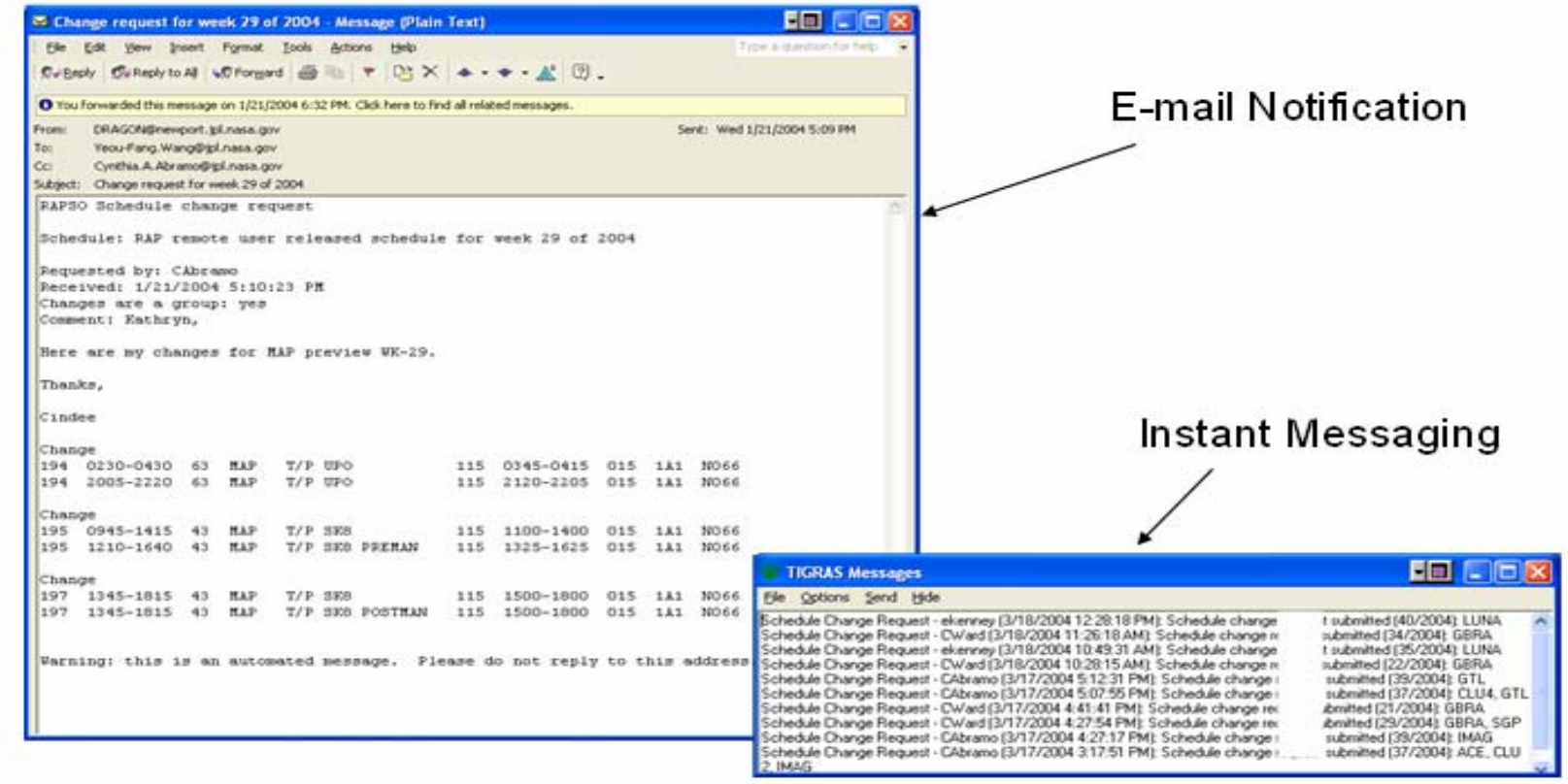
Conflict Resolution – Concept Views



Conflict Resolution – Concept Views



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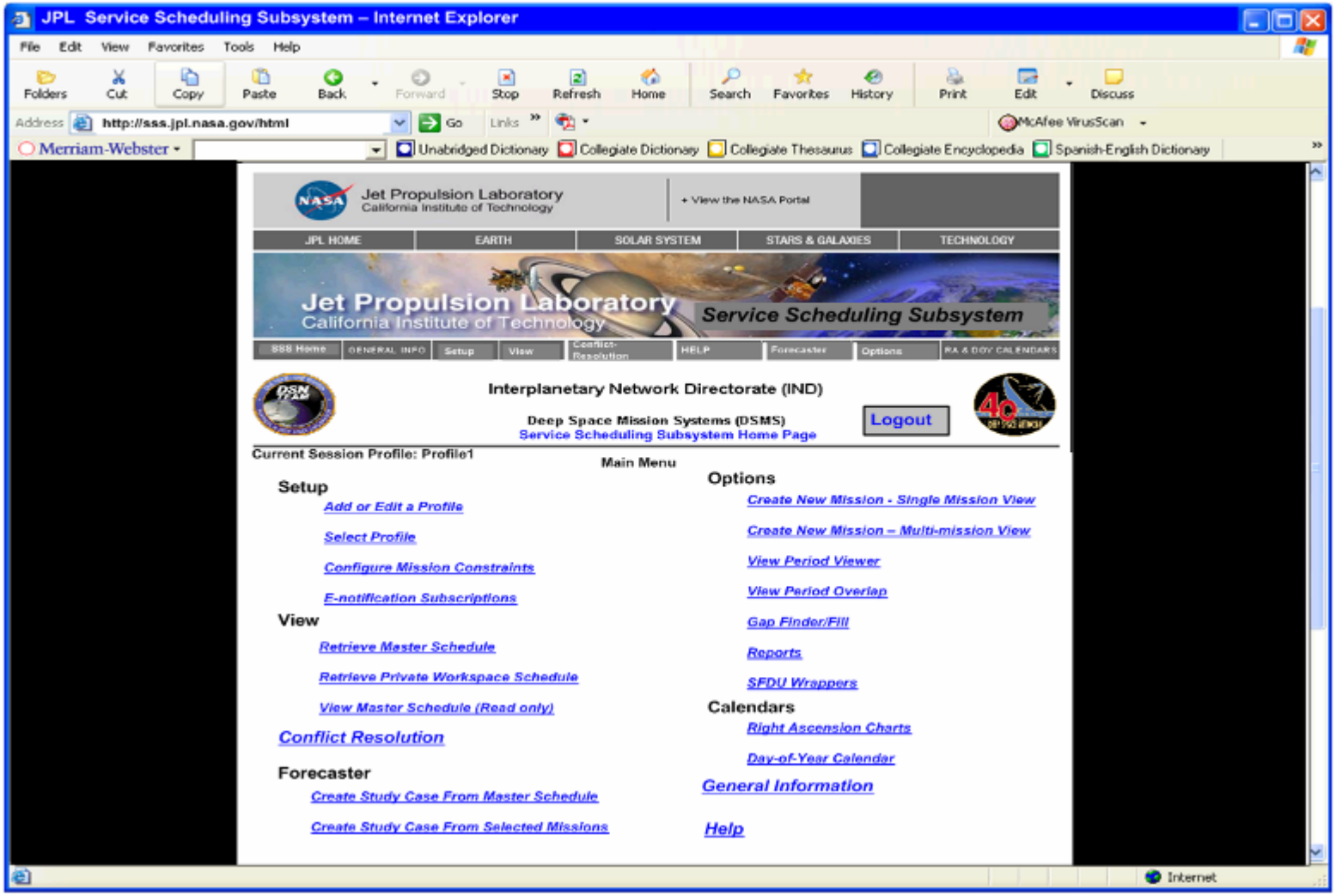
Service Scheduling Subsystem - Home Page



Next Steps

- Perform Alignment between the SSS Concept of Operations Document and the SSS Functional Requirements Document
- Update and Release Both if necessary
- Hold a Concept Review
- …

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DSMS Development, Operations and Services Program Office

DDOSO

(920)

W. Sible

JPL

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Agenda

- Office 920 Organization (formerly known as the Operations Office 930 & the Engineering Office 940)
- Tasks to be completed in this year
- Significant Operations Accomplishments & Plans

Consult your TMS Manager for details of schedule and functional capabilities

DDOSO Organization Concept

- Operations and Engineering integrated together
  - Vertical integration (requirements, design, deployment, & operations)
  - DSCC operations and maintenance, and JPL Central operations, will be involved in the ground floor of developments, both new and follow-on
    - Ensures operations needs are addressed (e.g., operations requirements, desired real-time metrics, system maintainability and ease of operations are included in designs)
    - Have a direct input into the decisions on resolving problems

- Four main offices organized to provide a "cradle-to-grave" process flow
  - Each office is responsible for the development, implementation and delivery, operations, and maintenance of their areas of concern
  - Each office can determine how a problem should be corrected (updates, operational procedures, training, etc.)
  - Offices work together on issues that span multiple offices

DDOSO Organization Concept (cont.)

- Additionally, there are two support groups
  - Development and Operations Engineering Staff
    - Responsible for technical coordination across the offices
    - Lead for cross office problem investigation
    - Across the board interface for operations and maintenance
  - Resource Manager
- All offices have the following functions:
  - Requirements analysis
  - Low level requirements generation
  - Development of trade-offs and cost estimating
  - Selection of program work content in response to SE requirements
  - Implementation and delivery
  - Equipment operations and maintenance
  - Monitoring of performance via DR (Discrepancy Report) analysis and mission feedback
- ITT (main O & M contractor) engineers are integrated into this structure

Resource Allocation Review Board

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920
DSMS DEVELOPMENT, OPERATIONS AND SERVICES PROGRAM OFFICE

Alaudin Bhanji, Mgr
Wayne Sible, Dep Mgr

ITT Program Manager, Pat Carr
Goldstone (ITT) Site Mgr, Sonny Giroux
Canberra Director, Peter Churchill
Madrid Director, Gregorio Pasero

Business Office Resources

Weni Wilson, Mgr (2x)
Mike Sapa, PRA (2x)
Kristi Dell'Aquila, PRA (2x)
Steve Marroquin, PRA-O&M Contracts (2x)

Administrative Staff

Mark Romejko, Sr. Administrator
Pat Lux, Administrator
Jeremy Mattes, APT
Lorraine Avila, Secretary
Lorraine Suwa, Secretary
Michele Sawnor, Secretary
Luanne Cathey, Secretary

Development & Operations Engineering Staff

Jeff Berner, Dev & Ops Chief Engr
Mike Levesque, Chief S/W Engr (313)
Sue Kurtik, Mission Support Mgr
Jeff Osman, DSN O&M CTM
Armond Salazar, DSN TMR
Joe Wackley, Chief Reliability Engr.
Ken Kimball, Process Engineering ◢

Offices 910, 911, 912, 960, 970, 980, and MMO

921
Service Management

Allen Berman, Mgr
Pat Beyer, Dep Mgr
Jim Hodder, Assist. Mgr, Ops

922
TT&C E2E Data Services

Ana Guerrero, Mgr
Miguel Marina, Dep Mgr

923
Antenna Front End & DSN Science Support

Dennis Buck, Mgr
Wendy Hodgin, Dep Mgr
Marty Slade, Asst. Mgr, Sci (331)

924
Infrastructure - Verification & Validation

Chuck Klose, Mgr
Dave Recce, Dep Mgr

◢ **Joint 920/912 Appointment**

Resource Allocation Review Board

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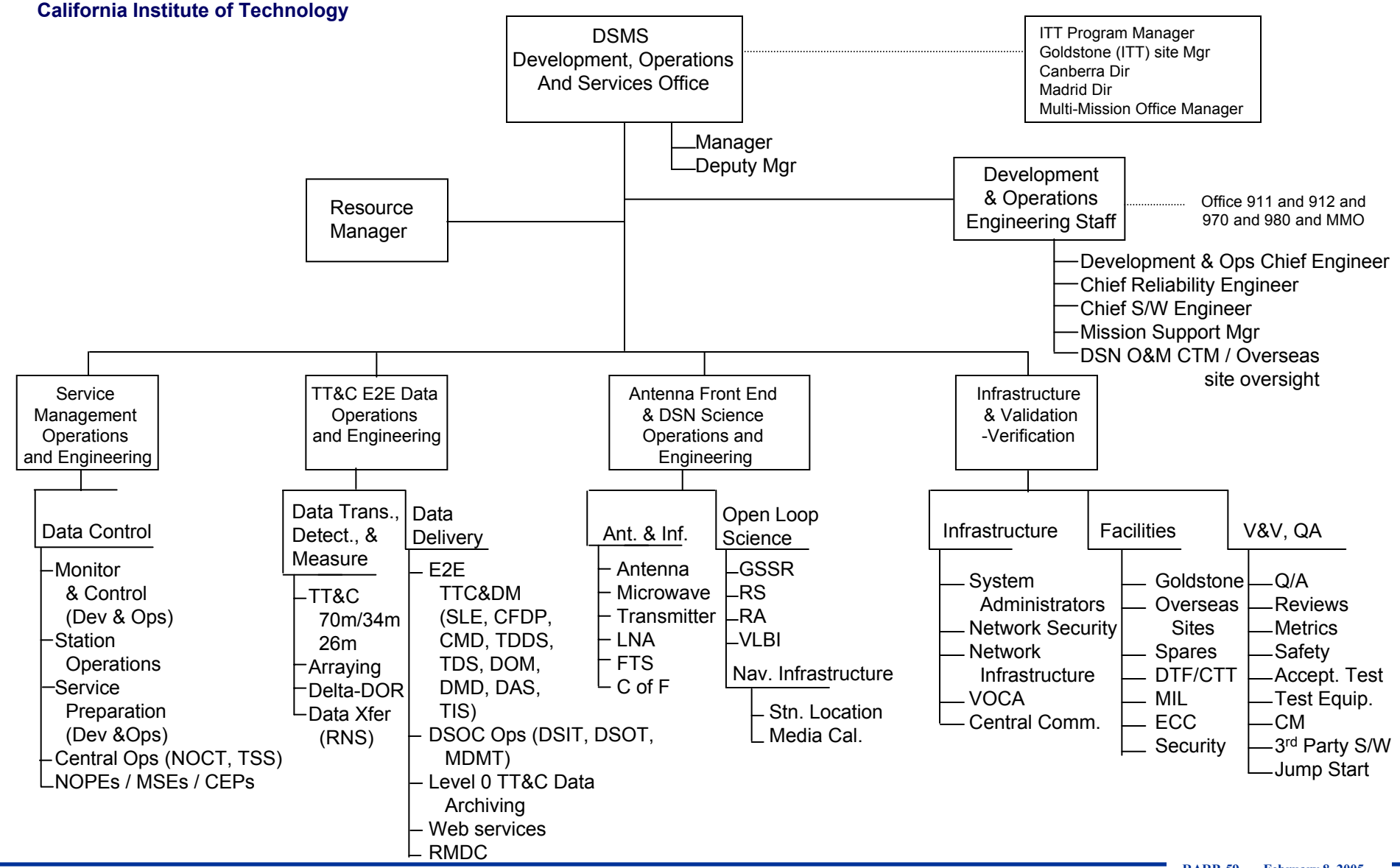

Key Tasks to be completed this year

- X/X/Ka-band feeds for BWG Antennas
  - DSS-34
- Antenna controllers for the 70m and 34m HEF
  - Will require significant downtime
- TTC UPL/DTT V5.5 & V5.7
- DSS-65 Relocation
- DSS-43 Hydrostatic Bearing Assembly (HBA) Task

X/X/Ka feeds

- WHAT:
  - Replace the X/X feeds at the BWG's with X/X/Ka-band feeds
- WHEN:
  - Next installation is at DSS-34 (2/15/05 - 4/24/05)
- IMPACT/BENIFIT ON CUSTOMERS:
  - Ka-band downlink capability
  - Improved X-band BWG downlink sensitivity at X-band
    - 0.5-2.5 dB depending on the operations mode and reference antenna

70m/34mHEF Antenna Controller Replacement (ACR)

- WHAT:
  - Replace the aging Antenna Pointing Assembly (MODCOMP computers)
- WHEN:
  - DSS-14 - First 70 meter installation was successfully completed on 1/11/05
  - DSS-65 - First 34 meter HEF installation - (1/31/05 - 9/01/05)
  - DSS-43 - Second 70 meter (7/18/05 - 1/1/06)
  - DSS-15 - Second 34 meter HEF (9/12/05 - 11/20/05)
- IMPACT ON CUSTOMERS:
  - Improved reliability
  - Long downtimes

TTC UPL/DTT V5.5

- WHAT:
  - Replace the legacy formatter card, throughput rate up to 10 Mbps
  - Increase turbo code rate to meet STEREO & MRO needs
  - Add features committed to MRO (initial 6 Mbps implementation)
  - Add operability features and anomaly fixes
  - Replace the exciter controller (OS-2 box)

- WHEN:
  - DSMS Delivery Review on 2/22/05

- IMPACT ON CUSTOMERS:
  - New features and improved reliability/operability
  - Corrects data dropouts seen by Spitzer

TTC UPL/DTT V5.7

- WHAT:
  - Completes MRO 6 Mbps capability
- WHEN:
  - DSMS Delivery Review on 5/15/05
- IMPACT ON CUSTOMERS:
  - Improved reliability/operability

DSS-65 Relocation

- WHAT:
  - Move "sinking" 34 meter HEF (DSS-65)
- WHEN:
  - 01/31/05 - 09/01/05 (shared downtime with ACR Task)
- IMPACT ON CUSTOMERS:
  - Long downtime
  - Improved reliability/operability
  - Will permit tracking speeds up to the required specification

Hydrostatic Bearing Assembly (HBA) Task

- WHAT:
  - Replace obsolete components (pumps, hoses, instrumentation, etc.) associated with the HBA
- WHEN:
  - DSS-14 - First 70 meter installation was successfully completed on 1/11/05 (shared downtime with ACR Task)
  - DSS-43 - Second installation, 7/18/05 - 1/1/06
- IMPACT ON CUSTOMERS:
  - Long downtime
  - Improved reliability/operability (reduced film height alarms)

Significant Operations Accomplishments September 2004 through January 2005

- Provided extremely high quality support to the Cassini Project
  - Huygens Probe Release on 12/25/04
  - Orbit Trim Maneuver (OTM) #10 on 12/27/04
  - Encounter and Playback of Iapetus Data on 01/01/05
  - Orbit Trim Maneuvers (OTMs) #10A, #11
  - Huygens Probe Decent/Relay/Playback on 1/14/05

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Significant Operations Accomplishments September 2004 through January 2005

- Provided extremely high quality support to the Deep Impact Launch on 01/12/05
  - Support of the launch and initial acquisition was successful.
  - The pre-Canberra telemetry provided by Universal Space Network (USN) was successful processed.
    - Within two weeks of receiving approval to proceed, the TTC&DM team successfully implemented, tested, trained and delivered the new capability to process the USN received telemetry.

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Significant Operations Plans Through August 2005

- Provide extremely high quality support to our DSN customers:
  - Cassini Encounters and Maneuvers
  - Rosetta EGA Closest Approach
  - Deep Impact Maneuvers, Impactor Release, Encounter & Playback
  - Messenger Maneuvers & Earth Flyby
  - NOAA-N Launch
  - Stardust Maneuver
  - Voyager DTR Playback
  - GOES N Launch
  - MRO Launch

- It will continue to be a very busy and challenging time for the DSN!!!

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Venus Express

Thomas W. Thompson

JPL

- Contents
  - Mission Overview
  - Science Instruments
  - Science Goals
  - DSN Support

ESA's Venus Express Mission will revolutionize our understanding of the evolution of the Venusian atmosphere.

ESA's Venus Express Mission satisfies many of the objectives identified in the Next Decadal Study

Its synergistic set of experiments measure key aspects of Venus encompassing:

- the surface,
- the middle and upper portions of the Venusian atmosphere,
- the interaction between the Venusian atmosphere and the solar wind.

- Venus Express is an important pathfinder for Venus Sample Return Mission

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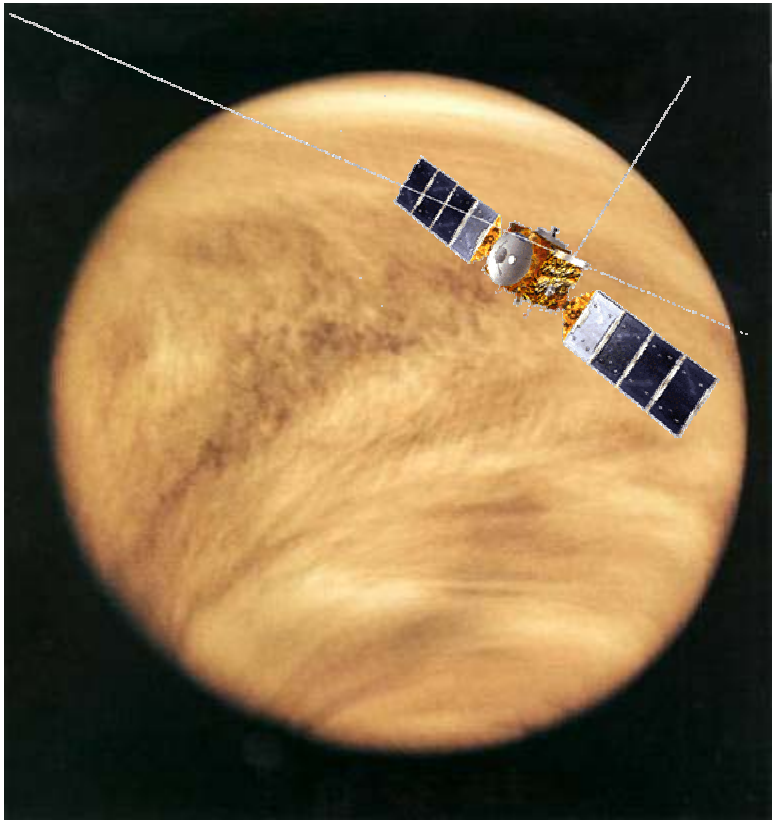
THE VENUS EXPRESS MISSION

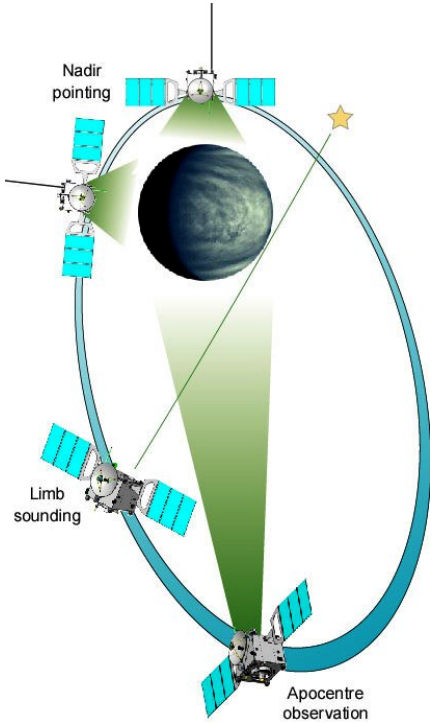
LAUNCH - 11/05



ARRIVAL - 04/06

1 venusian year = Earth 224 days

Prime Mission =
2 Venusian Years



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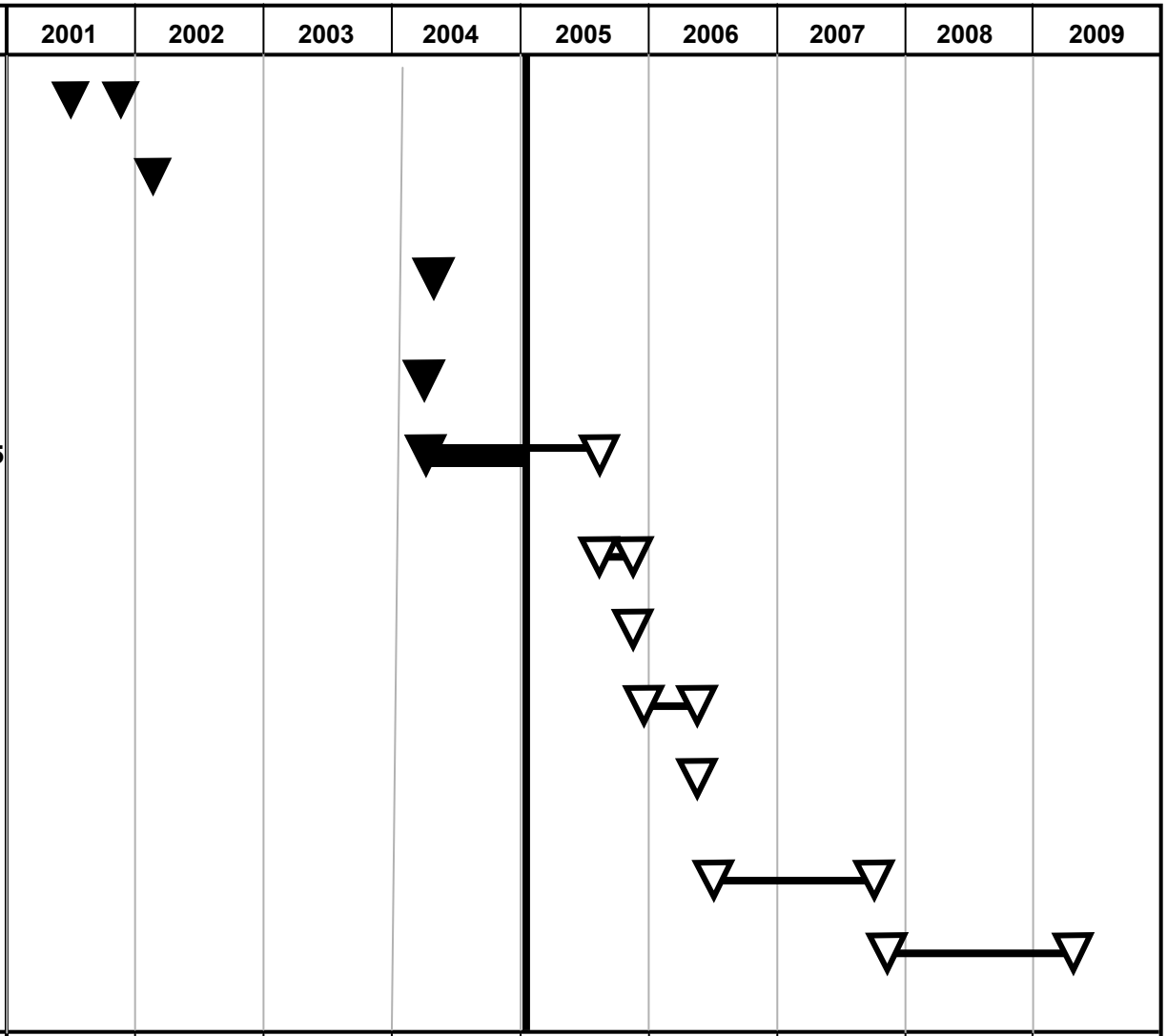
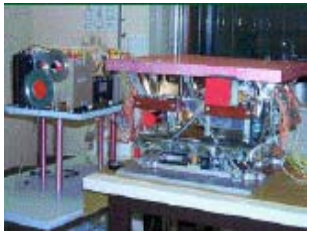
ACTIVITY	DATES
ESA Selection	Jul – Nov 2001
Preliminary Design Review	Jan 2002
Critical Design Review	Mar/Apr 2004
Payload Delivery	Mar 2004
Spacecraft integration	Mar '04 – July '05
Launch Campaign	Aug – Nov 2005
Launch (Nov 2005)	Nov 2005
Earth Venus Cruise	Nov '05 – Apr '06
Venus Orbit Insertion	Apr 2006
Prime Mission	Jun '06 – Oct '07
Extended Mission	Nov '07 – Apr '09

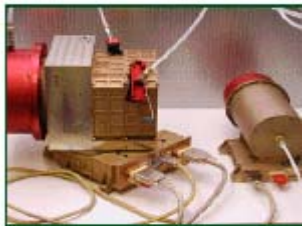


ACTIVITY DATES 2001 2002 2003 2004 2005 2006 2007 2008 2009

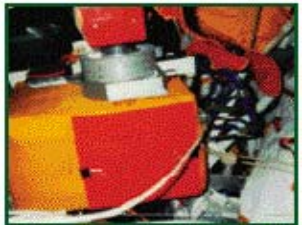
VENUS EXPRESS INSTRUMENTS



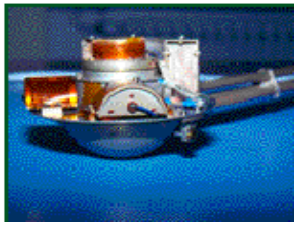
VIRTIS
P. Drossart, Obs. Meudon (FR)



ASPERA
S. Barabash, IRF Kiruna (SE)

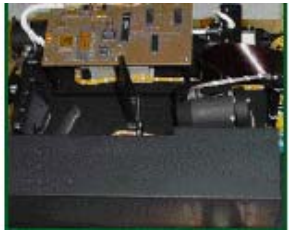


PFS
V. Formisano, CNR Rome (IT)

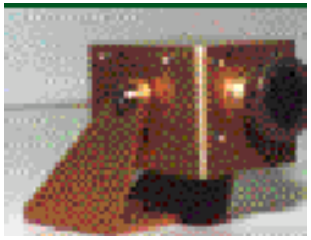


MAG
T. Zhang, OAW Graz (AT)

VeRA
B. Häusler, Univ.BW München (DE)



SPICAV
J-L.Bertaux, CNRS Verrières (FR)



VMC
W. Markiewicz, MPAe Lindau (DE)

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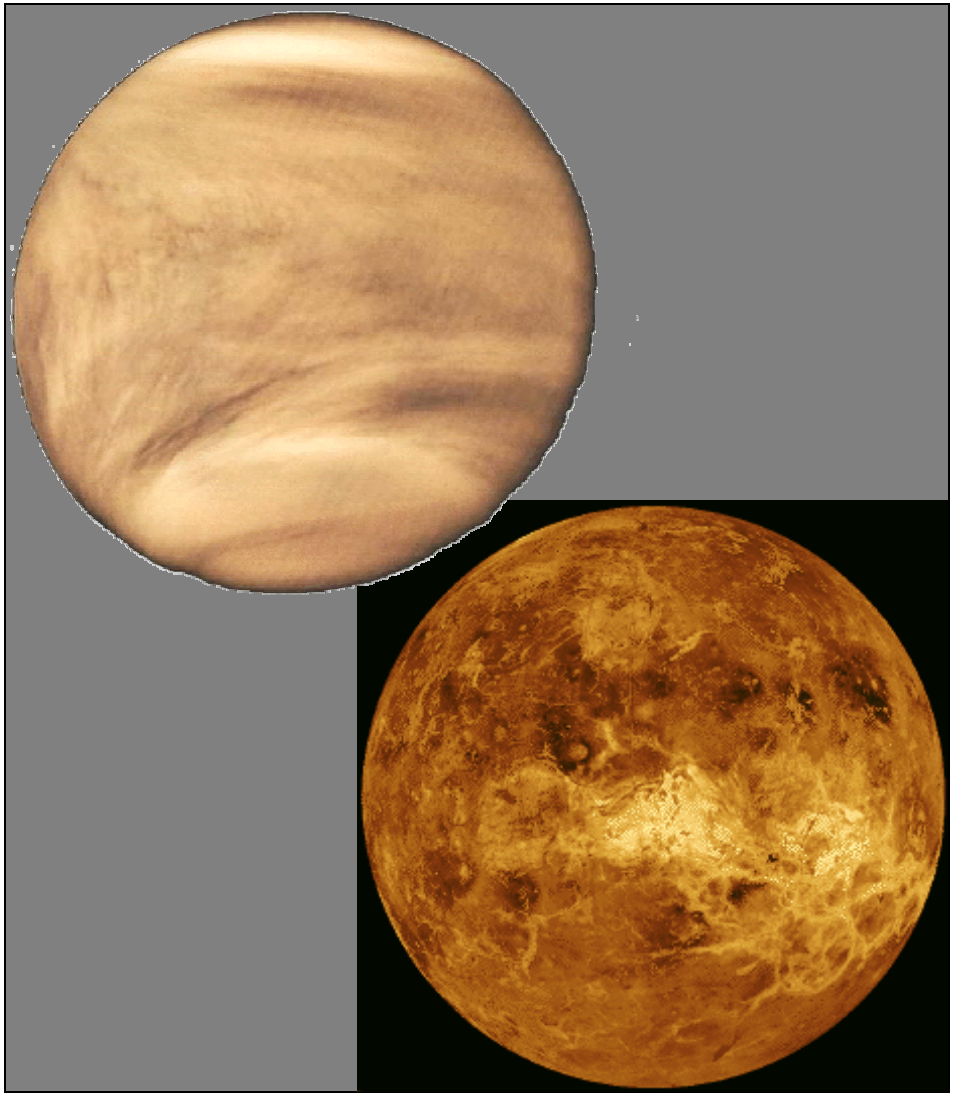
Mars Express Payload		Venus Express Payload	
Acronyms	Instruments	Acronyms	Instruments
Obiter			
HRSC	High-resolution stereo imager		
OMEGA	IR mineralogical mapper		
MARSIS	Subsurface sounding RADAR		
PFS	Planetary Fourier Spectrometer	PFS	Identical instrument
SPICAM	UV and IR atmospheric spectrometer	SPICAV	Improved IR channel
ASPERA	Energetic neutral atom analyser	ASPERA	Identical instrument
MaRS	Radio Science	VeRA	Upgraded with USA
		VIRTIS	VNIR-SWIR special imager (Rosetta)
		VMC	UV-VIS global imager (new)
		MAG	Magnetometer (new)
Lander			
Beagle-2	Suite of imagers, chemical analysers, robotic devices, & meteo sensors	(H) Potentail replacement by descent probe under evaluation as a collaboration with Russia	
TOTAL MASS(kg)	175	104	

MAJOR SCIENCE GOALS

- Space environment:
  - **Ionised plasma environment**
  - **Interaction with solar wind**
- Atmosphere:
  - **Mechanisms of general atmospheric circulation**
  - **Greenhouse effect**
  - **Physics & chemistry of cloud layer**
  - **Composition & chemistry of lower atmosphere**
  - **Atmosphere-surface interaction**
- Solid planet:
  - **Surface IR topography**



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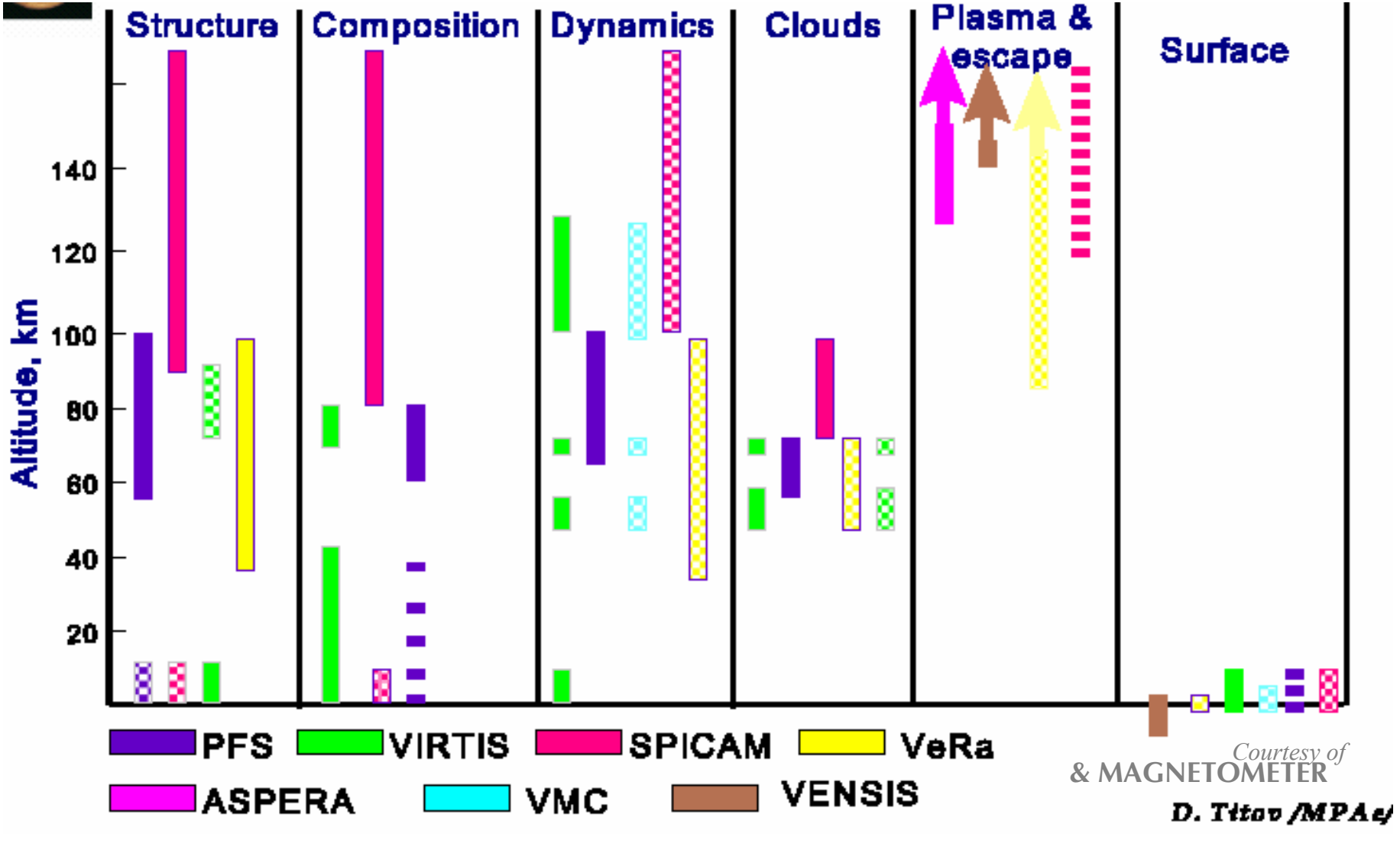

DSN support to the Venus Express Mission

- Post Launch Tracking
  (assure round-the-clock coverage)
- Cruise and Approach Navigation Tracking
  (Delta-DOR, VLBI technique for location in plane of sky)
- VOI Support

- Radio Science Occultation Observations
  (2 wavelengths, S- and X-band, to separate ionosphere from neutral atmosphere)
- Radio Science Bistatic Radar Observations
  (provides S-Band and larger aperture, stronger echoes)
- Conduct Solar Corona Observations
  (Use 34-m and 70-m)

- Augment Data Downlink during Science Campaigns
  (Venus Movies - Use 70-m)

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ST-5 Mission Requirements

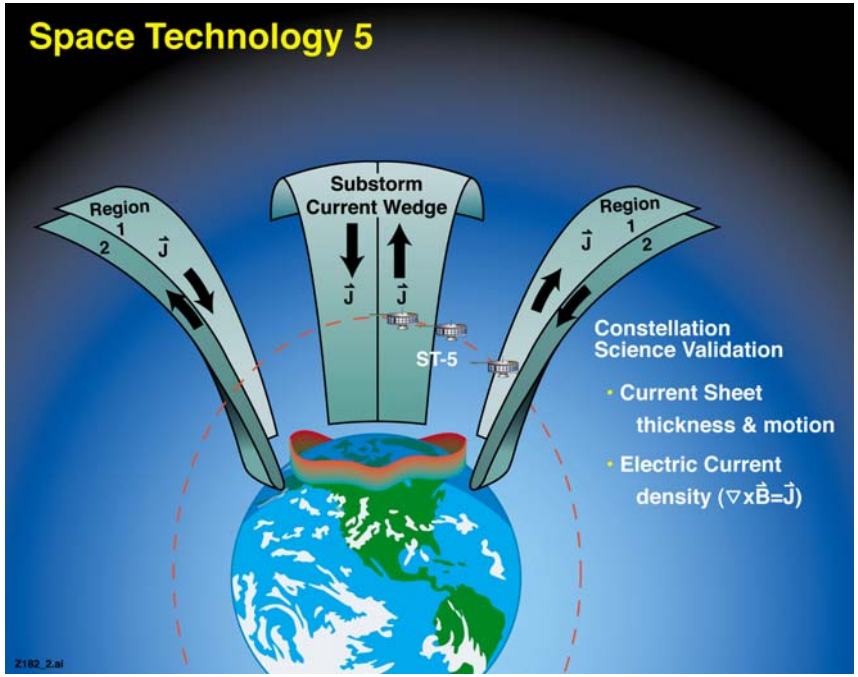
Candace Carlisle / Deputy Project Manager
Robert Shendock / SGT Inc

Overview

- Mission Overview
  - Mission Requirements
  - Background
  - Mission Profile
  - Constellation Operations
  - DSN Communication Requirements
- Requirements Overview
- RF Visibilities
- Support Types
  - Type A: Single Spacecraft Contact
  - Type B: Near-Simultaneous Contacts

ST5 Mission Requirements

- Design, develop, integrate, test and operate three full service spacecraft, each with a mass less than 25kg, through the use of breakthrough technologies
- Demonstrate the ability to achieve accurate, research-quality scientific measurements utilizing a constellation of 3 nanosatellites, each with a mass less than 25-kg
- Execute the design, development, test and operation of multiple spacecraft to act as a single constellation rather than as individual elements.



Background

- ST5's original design was for a GTO, equatorial orbit.
- In early 2002, GSFC and JPL agreed that ST-5 would use the DSN for communications.
- Redesigned mission for Pegasus launch into polar elliptical orbit in spring 2004.
- DSN stations already have the capability to support ST-5 (uplink, downlink, tracking)
- ST-5/DSN compatibility has already been demonstrated (using ST-5 prototype transponder)
- Best visibility for new orbit is at Canberra

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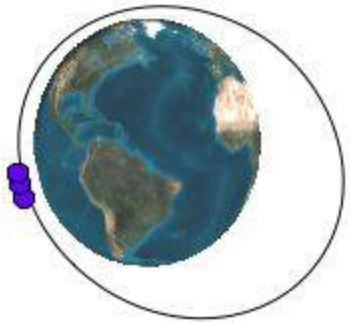
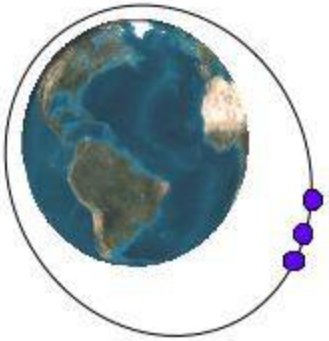
ST5 Mission Profile

- Launch Timeframe: February 28 - March 31, 2006
- Launch Site: Vandenberg AFB, Lompoc, CA
- Mission Duration: 90 days
- Eclipses: None due to earth shadow, a few due to moon shadow
- Perigee: 300 km
- Apogee: 4500 km
- Inclination: 105.6 deg (sun synchronous)
- Period: 136 min
- Number of orbits/day: about 10.5
- RAAN: 68 for Mar 1 launch, increasing 1 deg/day for launch later in launch window (full sun 6 AM - 6 PM)
- Argument of Perigee at Launch: 160 deg
- Rotation of Apsides: -1.2 deg/day (into the southern hemisphere)
- Constellation Configuration: "String of Pearls"

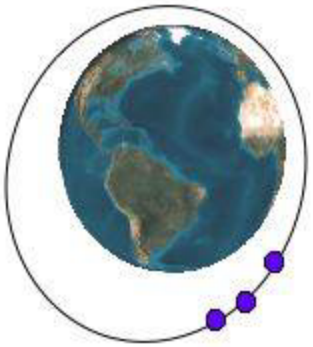
Constellation Operations



At deployment
S/C are meters apart
Argument of perigee:
~160°



Science Val 1 Configuration
~21 days after launch
S/C spacing: ~25-50km, ~60-150 km
Argument of perigee: ~135°



Science Val 2 Configuration
~63 days after launch
S/C spacing: ~40-100km, ~80-200 km
Argument of perigee: ~84°

- Two Constellation Formations will be achieved during 90 day mission
  - Each Constellation maneuver involves:
  - Initial Maneuver (Delta-V ~ 0.2 m/s to 1.0 m/s)
  - Slow increase in separation between spacecraft over course of days
  - Braking maneuver (Delta-V ~ 0.2 m/s to 1.0 m/s)
- Each S/C will also require attitude maneuvers every 10 - 20 days for drag torques, etc.

Contact Time Requirements

- Command Uplink:
  - 10 minutes per day per s/c, at 1 kbps rate
- Tracking and Orbit Determination:
  - One tracking pass per spacecraft per day for ~10 minutes
- Downlink:
  - 13 minutes per spacecraft per day
    - Supports a core science requirement
    - Using a 200Kbps downlink rate (convolutional encoding off)
    - DSN loading study indicates this can be met ~80% of the time
    - Will schedule contacts >= 10 minutes up to ~30 minutes

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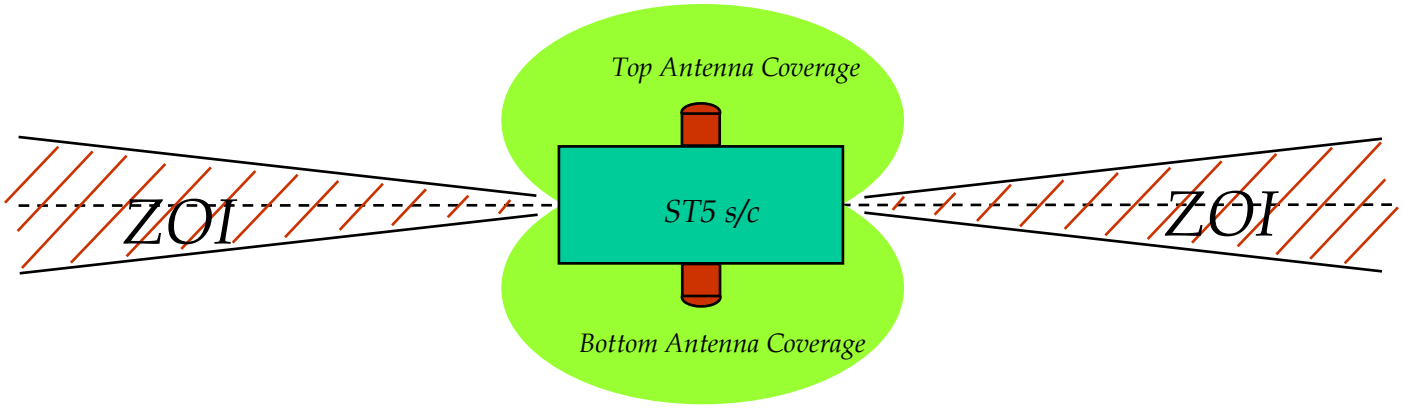
RF Visibilities

- Polar Orbit requires different antenna coverage than previous GTO
- Modified antenna implementation
  - Equal coupling to both top & bottom antennas
  - Will use evolved antenna on all 3 spacecraft
- Two antennas have a Zone Of (destructive) Interference (ZOI)
  - Approximately +/- 7 degrees from spacecraft "equator"
  - Ops to predict and report ZOI times



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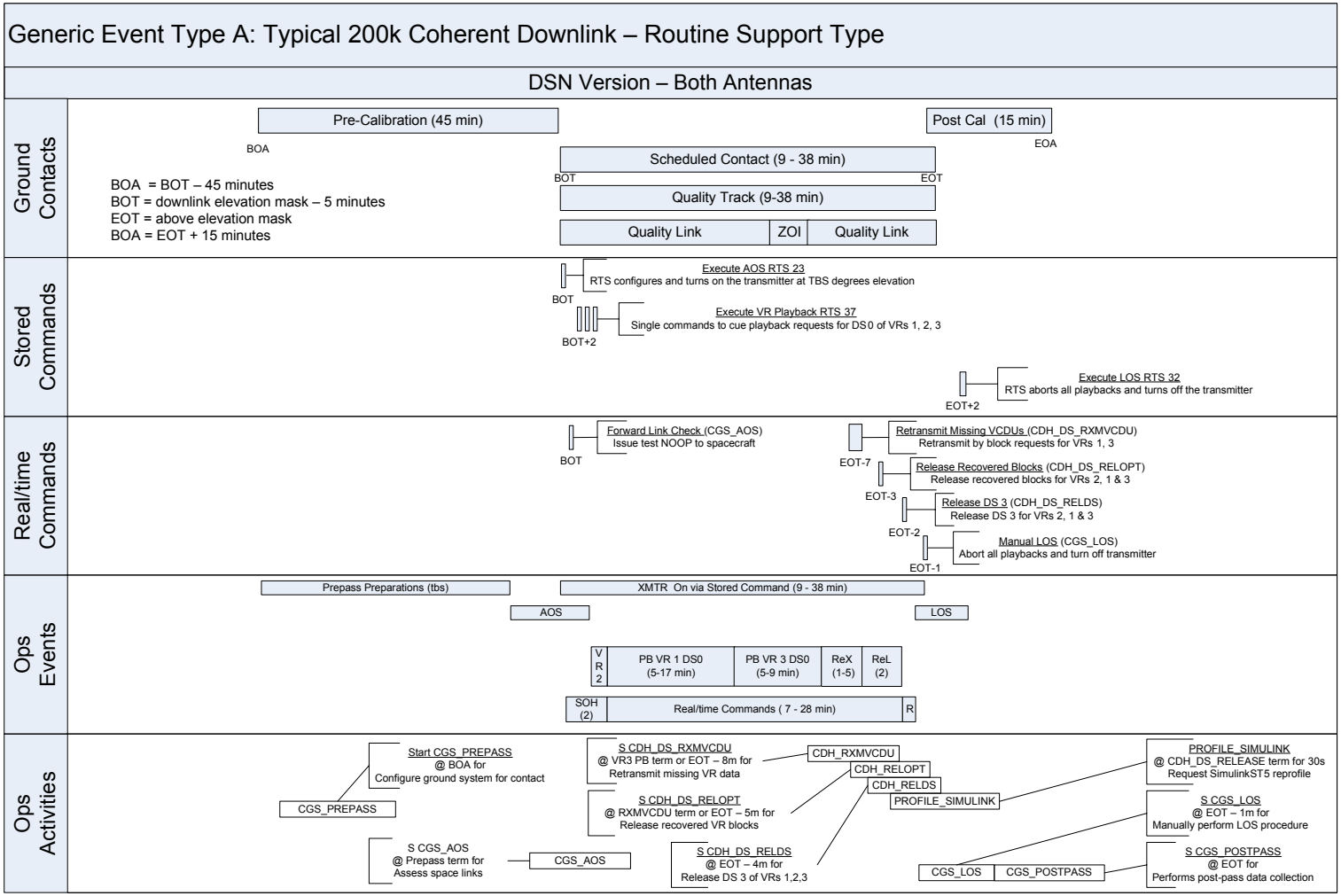
Generic Track Support Types

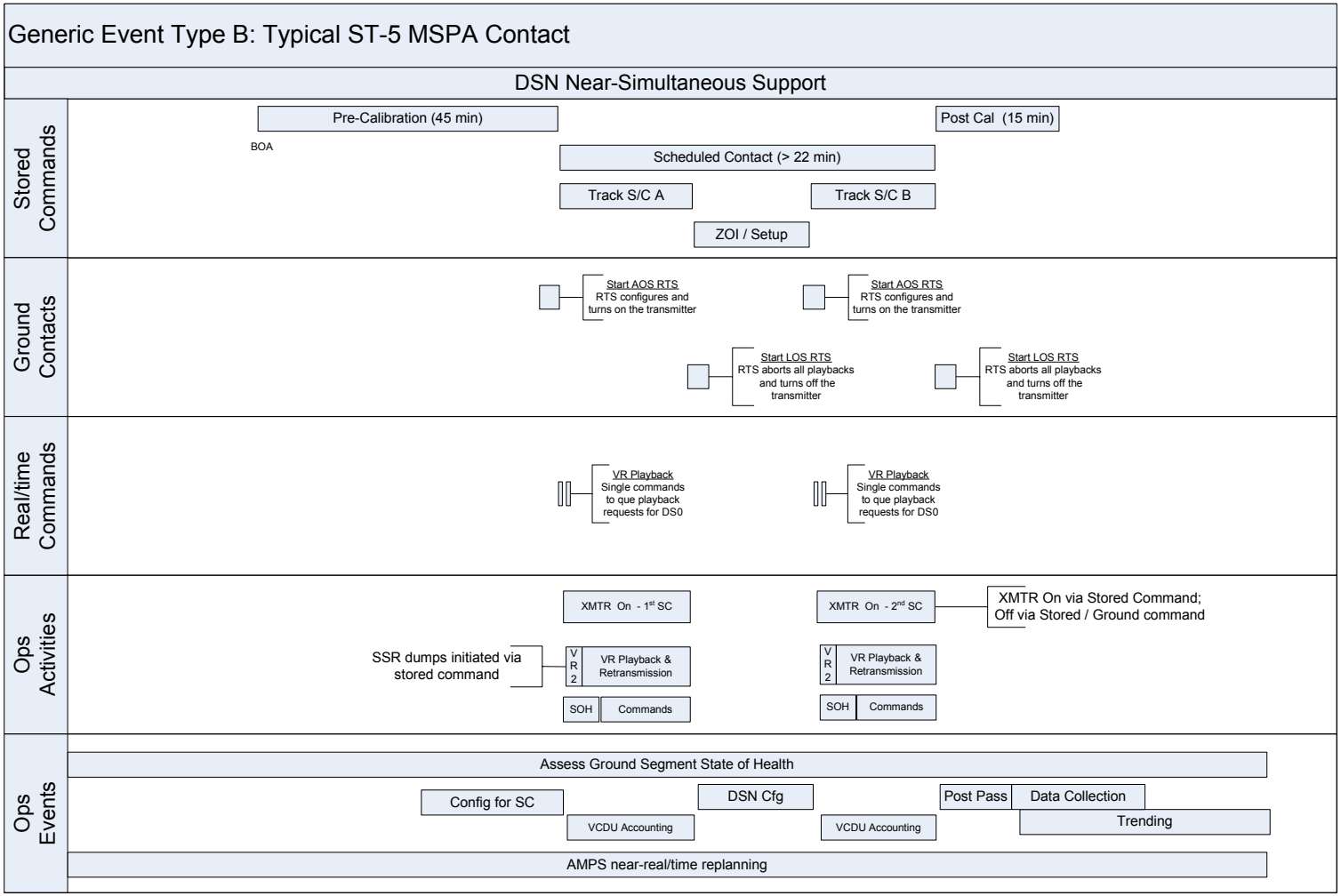
- Generic support types used for scheduling and support
  - Types are a function of data rate, initial coherency, and single/multiple spacecraft support
  - The compactness of the constellation (2 or more) allow ST-5 to schedule Near-Simultaneous Contacts with both networks

			No. of spacecraft		
Event Type	**Data Rate**	**Coherency**	**DSN**	**GN**	**Description**
1	1k	Non-coherent	1	1 - 3	Contingency support
2	1k	Non-coherent	2	N/A	Contingency support
3	1k	Coherent	1	1 - 3	Post-launch support
4	1k	Coherent	2	N/A	Post-launch support
5	100k	Non-coherent	1	1 - 3	Blind or LOF acquisition
6	100k	Non-coherent	2	N/A	Blind or LOF acquisition
7	100k	Coherent	1	1 - 3	Routine support type
8	100k	Coherent	2	N/A	Periodic or Special support type
9 (A)	200k	Non-coherent	1	1 - 3	Routine support type
10	200k	Non-coherent	2	N/A	Periodic or Special support type
11 (A)	200k	Coherent	1	1 - 3	Routine support type
12 (B)	200k	Coherent	2	N/A	Periodic or Special support type

Type 11 (A): Single Spacecraft Coherent Acquisition



Type 12 (B): Near-Simultaneous Coherent Contact



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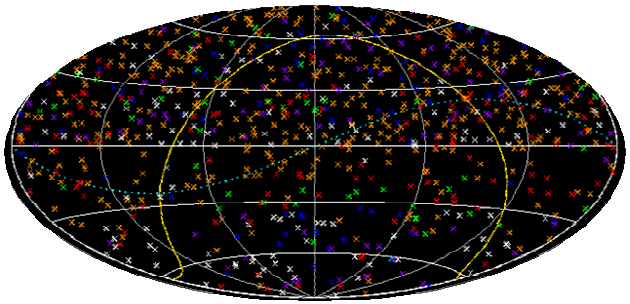
Reference Frame Calibration

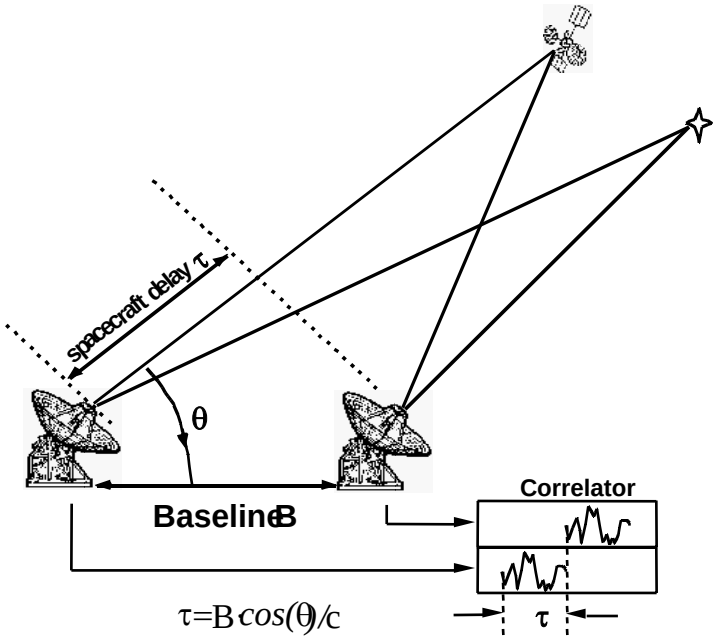


Chris Jacobs

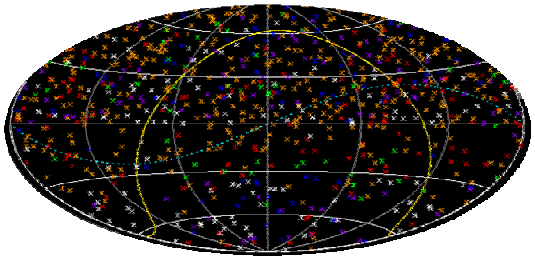
JPL

Jet Propulsion Laboratory
California Institute of Technology

- What is VLBI?
- How does it help the DSN and its missions?
  - ΔDOR navigation
  - Mars ephemeris
  - Calibrates:
    Earth Orientation, station locations
  - Physical Models for upcoming DSN array



- Where do VLBI scheduling requirements come from?
  - Two stations at a time
  - Two baselines within 6 weeks (CA-Aust, CA-Spain)
  - 24 hour duration
  - S/X (HEFs) and X/Ka (BWGs)



How does VLBI work?

- Relies on point source at infinity
  - Extragalactic "nebulae" idea from 18th c.?
  - *Active Galactic Nuclei*
  - *Concept: Navigate by "fixed" stars*
- Advantages: sources don't move

Credit: Hubble Deep Field, NASA, STScI.

BUT . . .

- The price to be paid is
  - Very weak sources 1 Jy = 1.0E-26 watt/m**2/Hz
  - need lots of square meters => 34 - 70m Antenna
  - lots of Hz bandwidth => 10-100 Mbps
  - low system temperature => Tsys = 20-40 Kelvin

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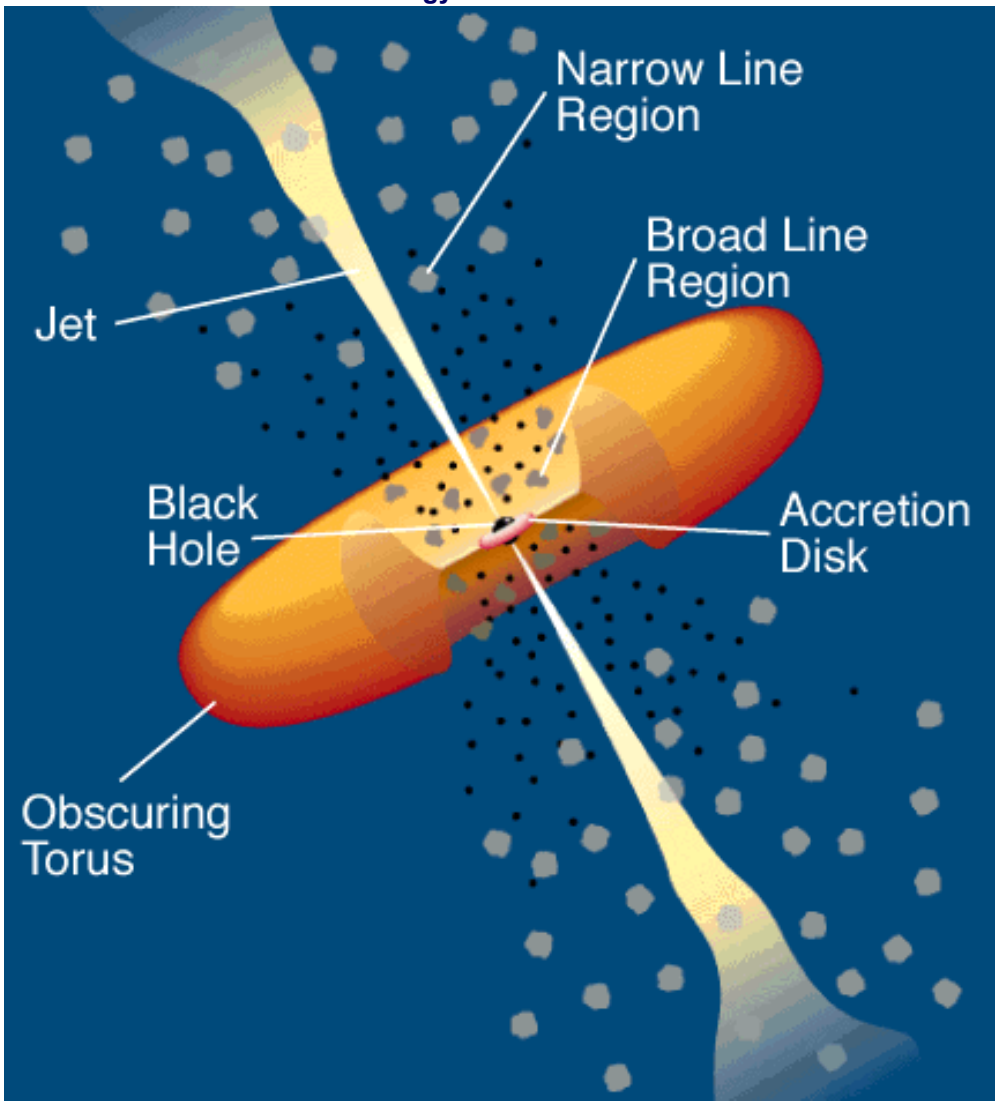


(Credit: C.M. Urry and P. Padovani)

http://heasarc.gsfc.nasa.gov/docs/objects/agn/agn_model.html

Schematic of *Active Galactic Nuclei*

Redshift z~ 0.1 to 5

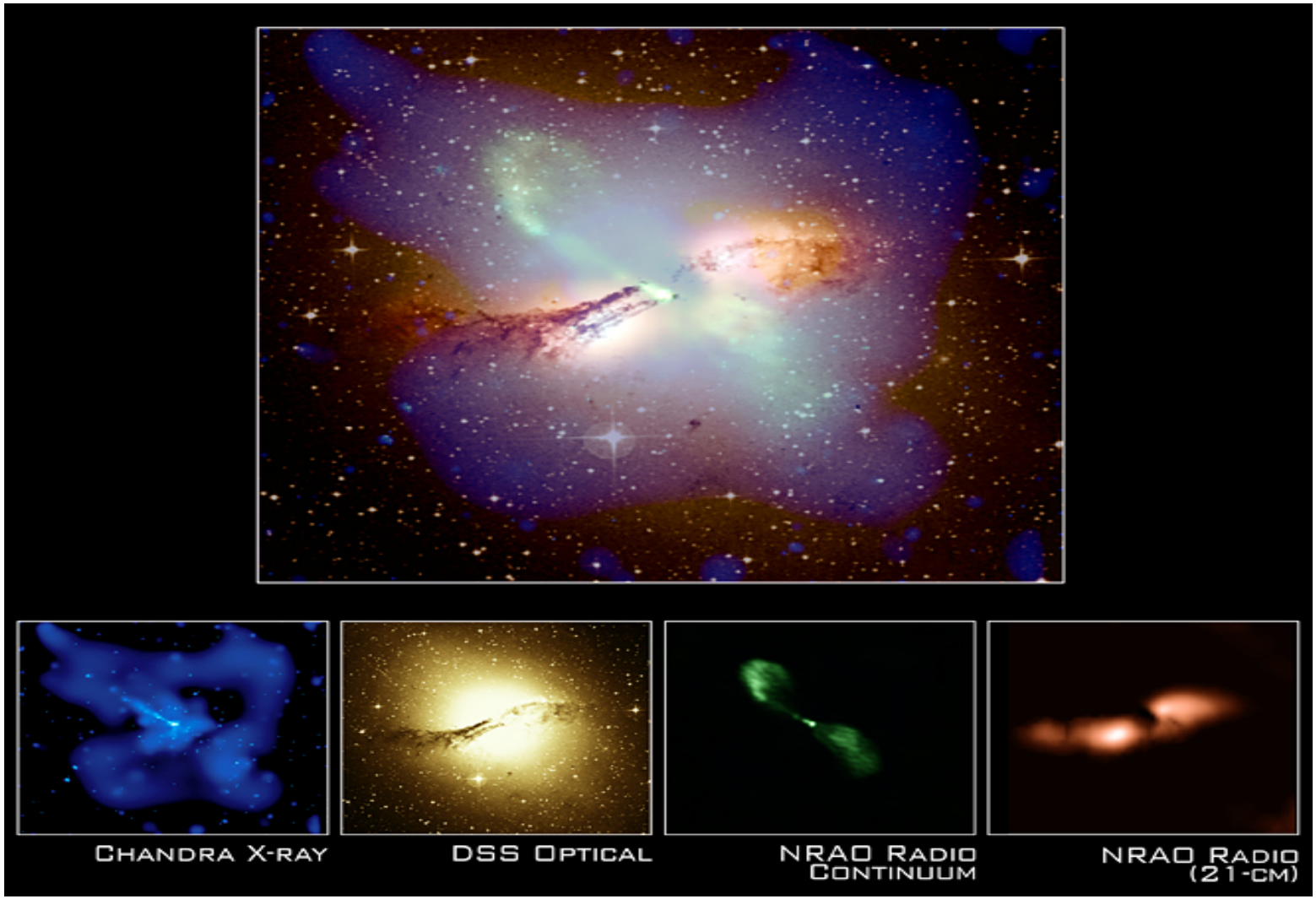
Distance:
billions light years

Parallax = 0

Proper motion
< 0.1 nrad/yr

Centroid of radiation Gets closer to central engine (black hole) As one goes to higher Frequencies, therefore,

K/Ka/Q better than X



Centaurus-A

Credits: X-ray (NASA/CXC/M. Karovska et al.); Radio 21-cm image (NRAO/VLA/Schiminovich, et al.), Radio continuum image (NRAO/VLA/J.Condon et al.); Optical (Digitized Sky Survey U.K. Schmidt Image/STScI)

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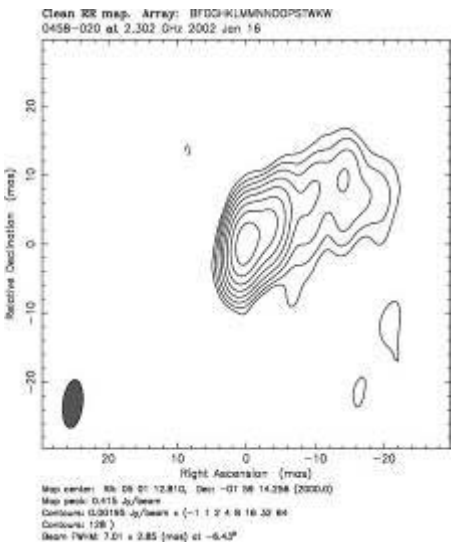

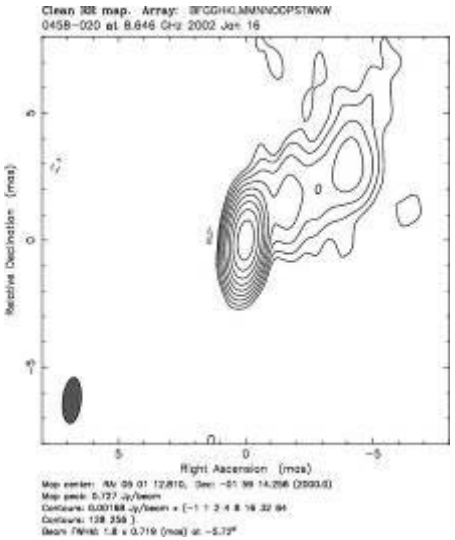

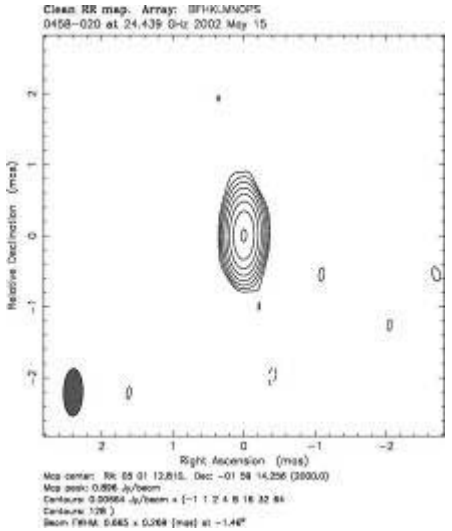

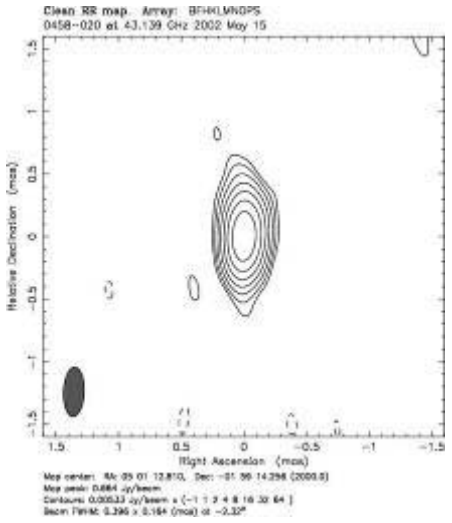

S-band
2.3 GHz
13.6cm

X-band
8.6 GHz
3.6cm

K-band
24 GHz
1.2cm

Q-band
43 GHz
0.7cm

The sources become better at Ka-band!

Ka-band
32 GHz
0.9cm

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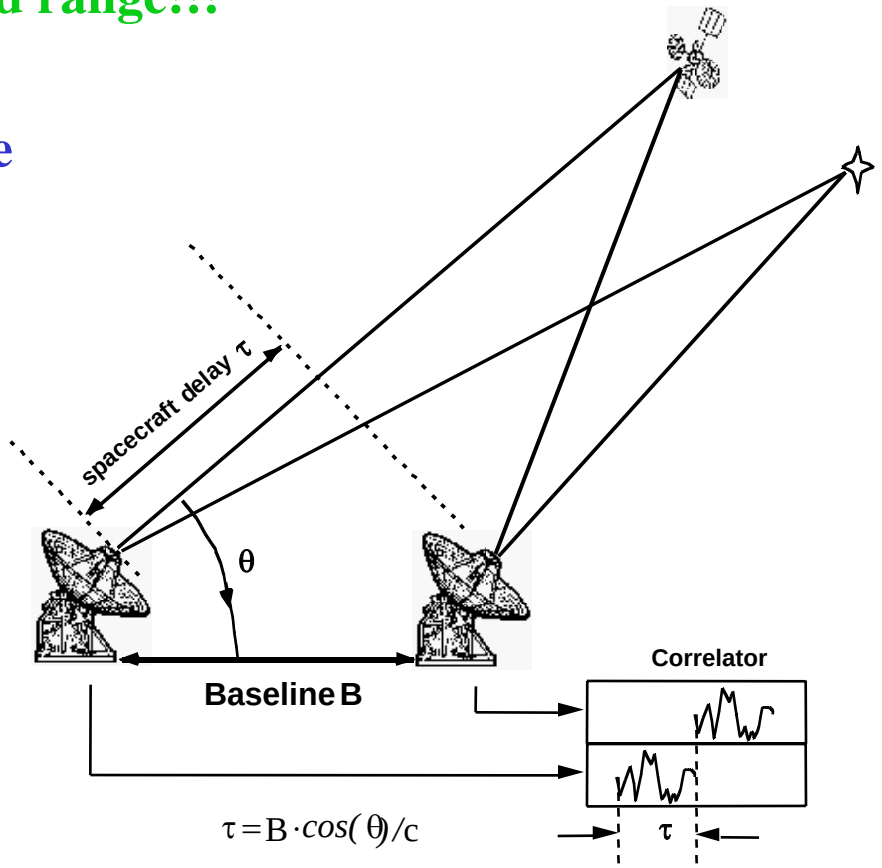
- **ΔDOR is complementary to Doppler and range!!!**

- **Doppler/Range measures radial distance**

- **ΔDOR measures angles**
  by cross-correlating signals
  from two (2) stations

- **Double-differencing cancels**
  common error sources
  - **instrumental effects**
  - **clock errors**
  - **media effects**
  - **baseline uncertainty**



WHY SHOULD YOU CARE?

- Mars ephemeris/frame tie improves our knowledge of where the planets are located.
  This is needed for all missions.

- Earth Orientation determined relative to radio frame
  - GPS constellation node drifts
  - VLBI calibrates UT1 component of Earth Orientation for all missions

- ΔDOR fiducials are sources from radio frame
  This helps navigate many missions.

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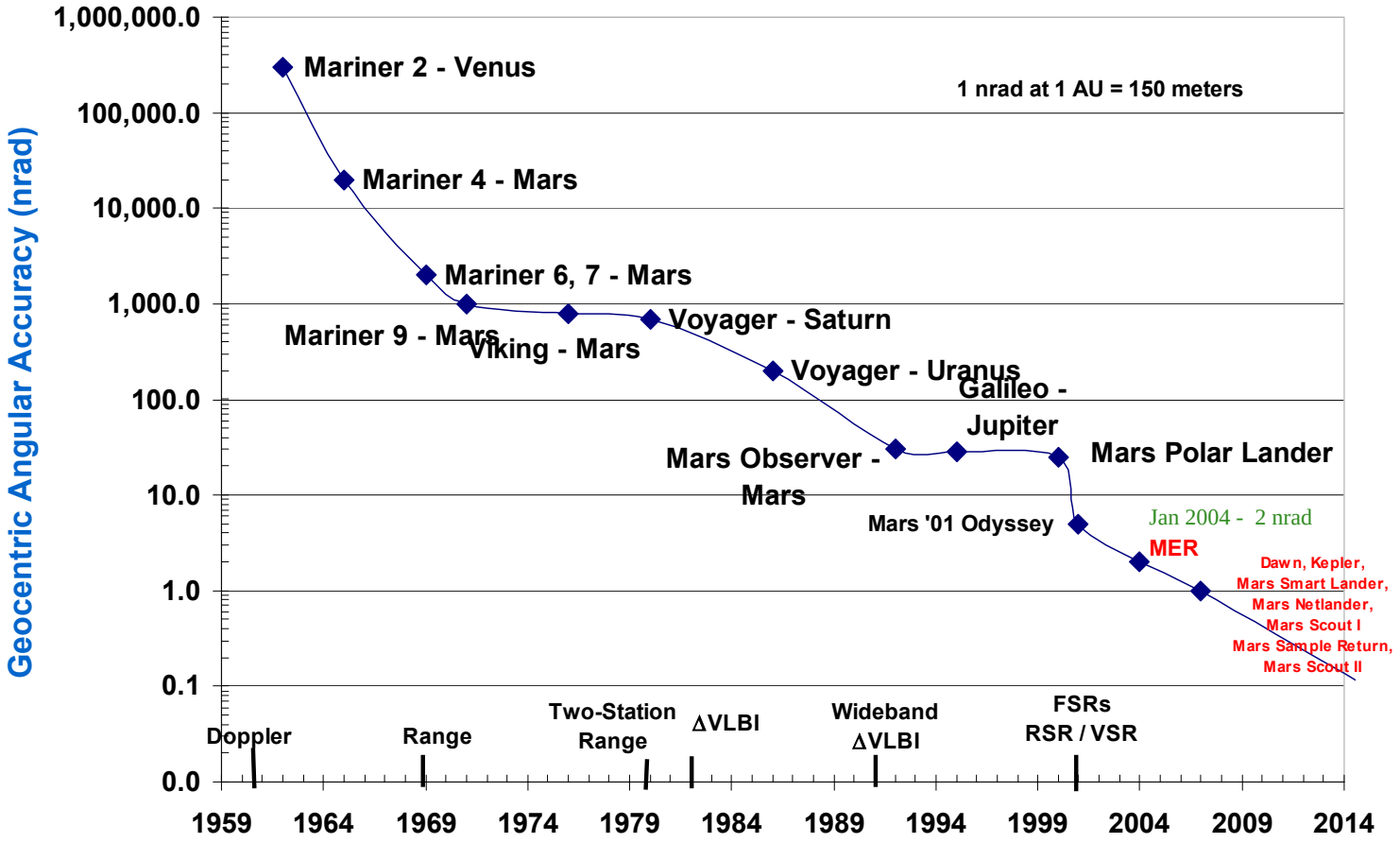
DSN Nav Accuracy

1959-2015



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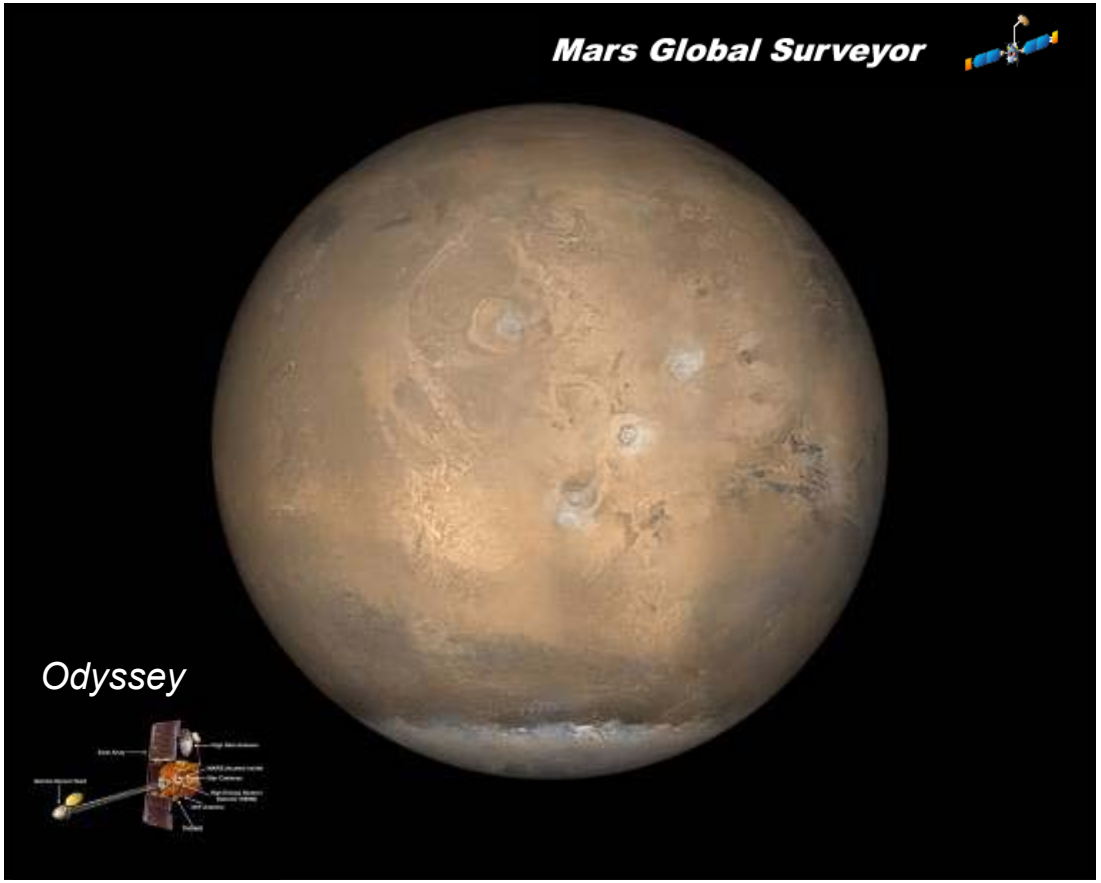
Mars Ephemeris / Frame Tie

- **Jim Border *et al***
- **~ 40 ΔDOR measurements**
  - **MGS and**
  - **Odyssey**
- **Mars residuals**
  - **3X improvement!!**
  - **1.5 part per billion**
- **More data on the way!!**
  - **Accuracy may improve to better than a part per billion.**



Credit: NASA, JPL/Caltech: www.jpl.nasa.gov

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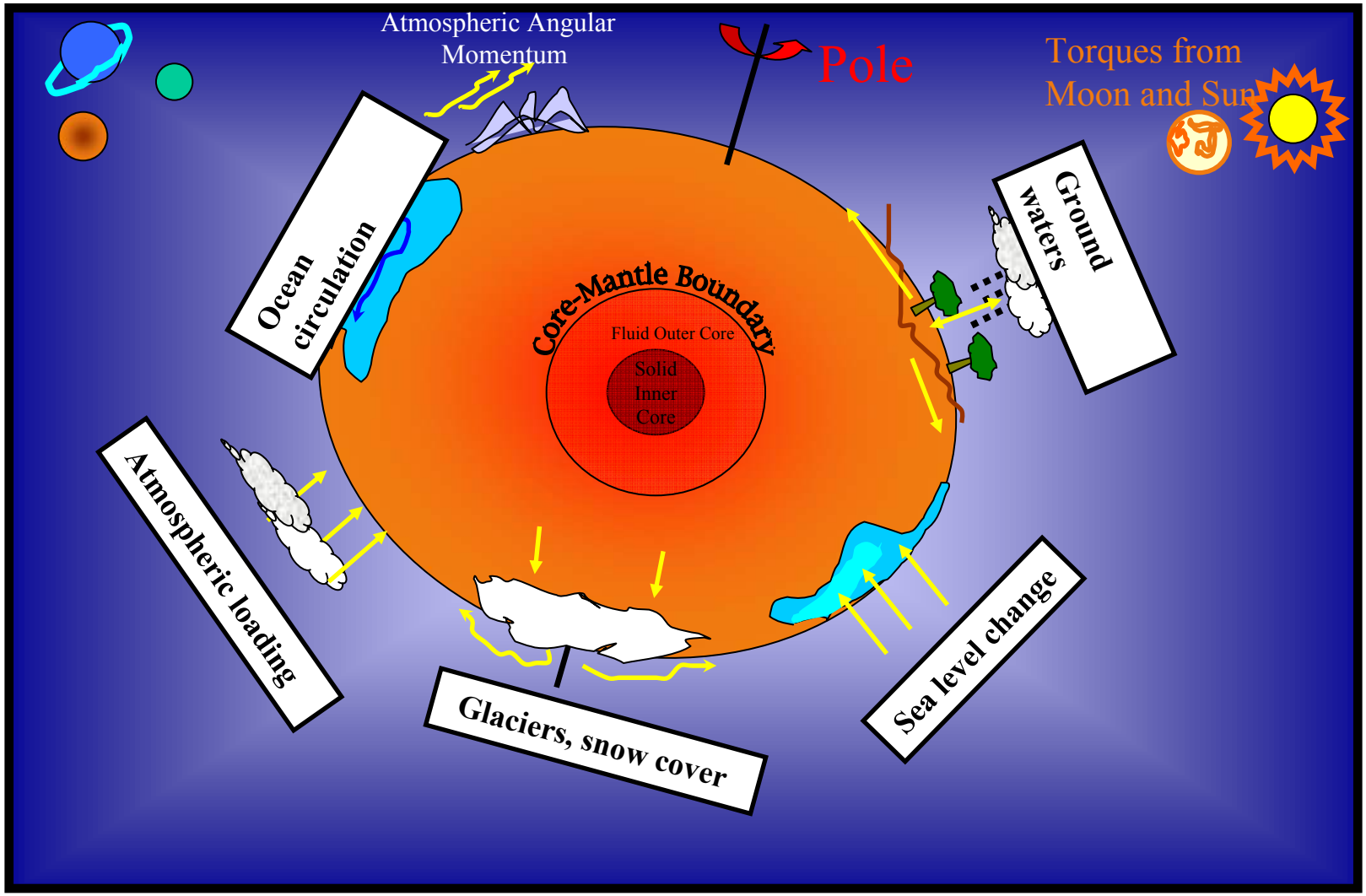

Credit:After Kurt Lambeck et al, The Earth's Variable Rotation, Cambridge, 1980

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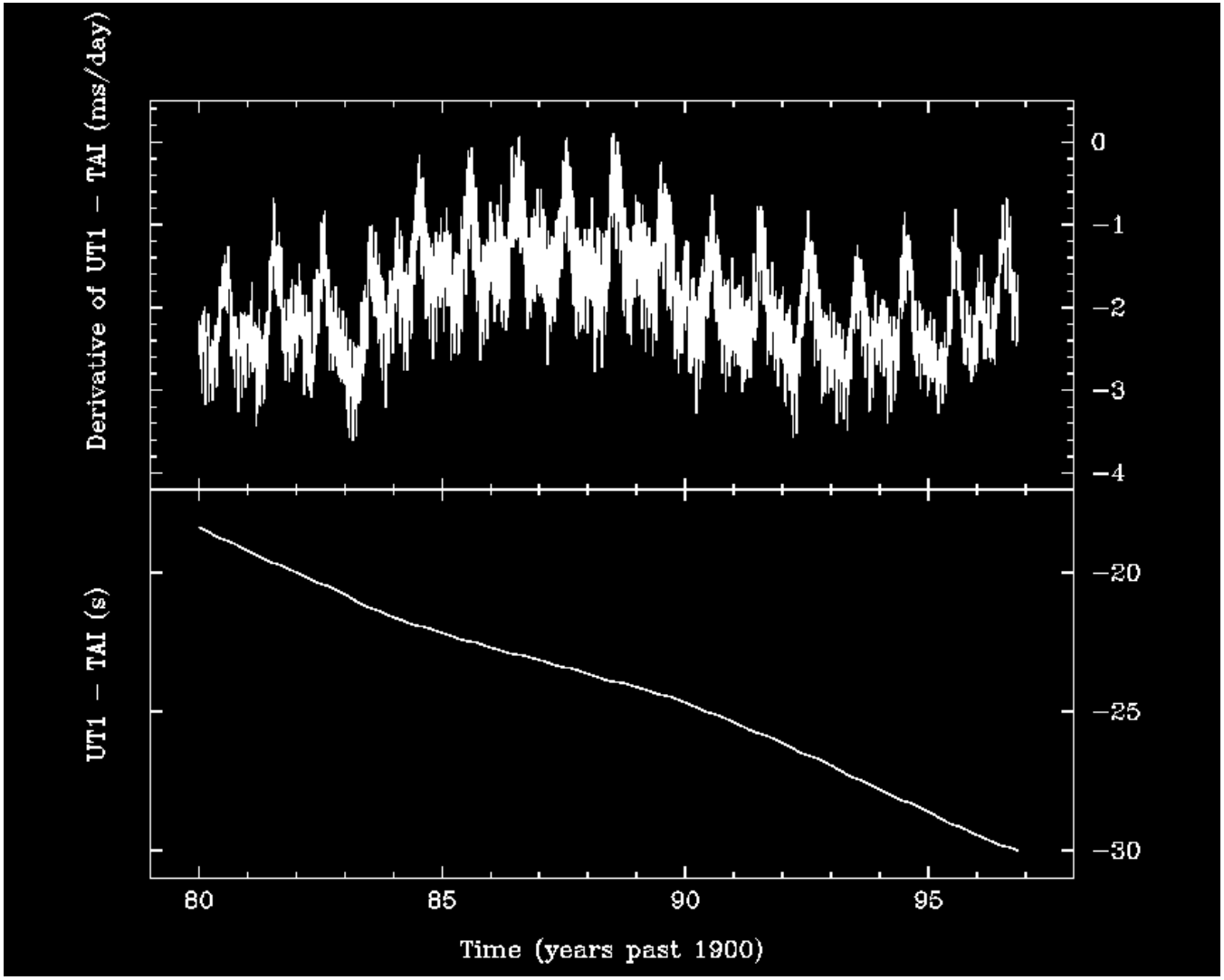

Credit Sovers, Fanselow, Jacobs, Rev Mod Phys 70, 4, Oct 1998.

Length Of Day Spectrum

and

UT1 -- TAI

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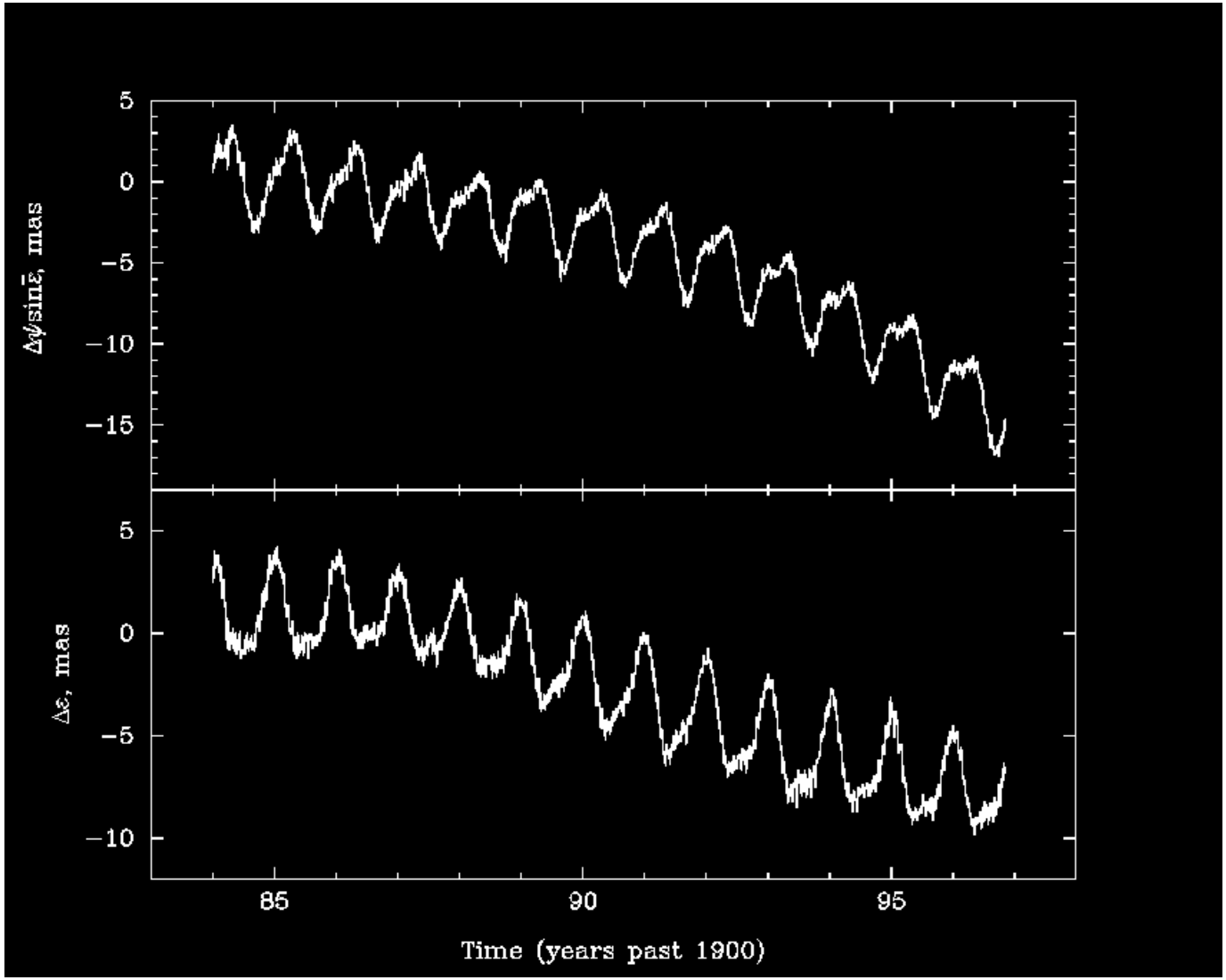

Credit Sovers, Fanselow, Jacobs, Rev Mod Phys 70, 4, Oct 1998.

Nutation:

Celestial Pole moves in space

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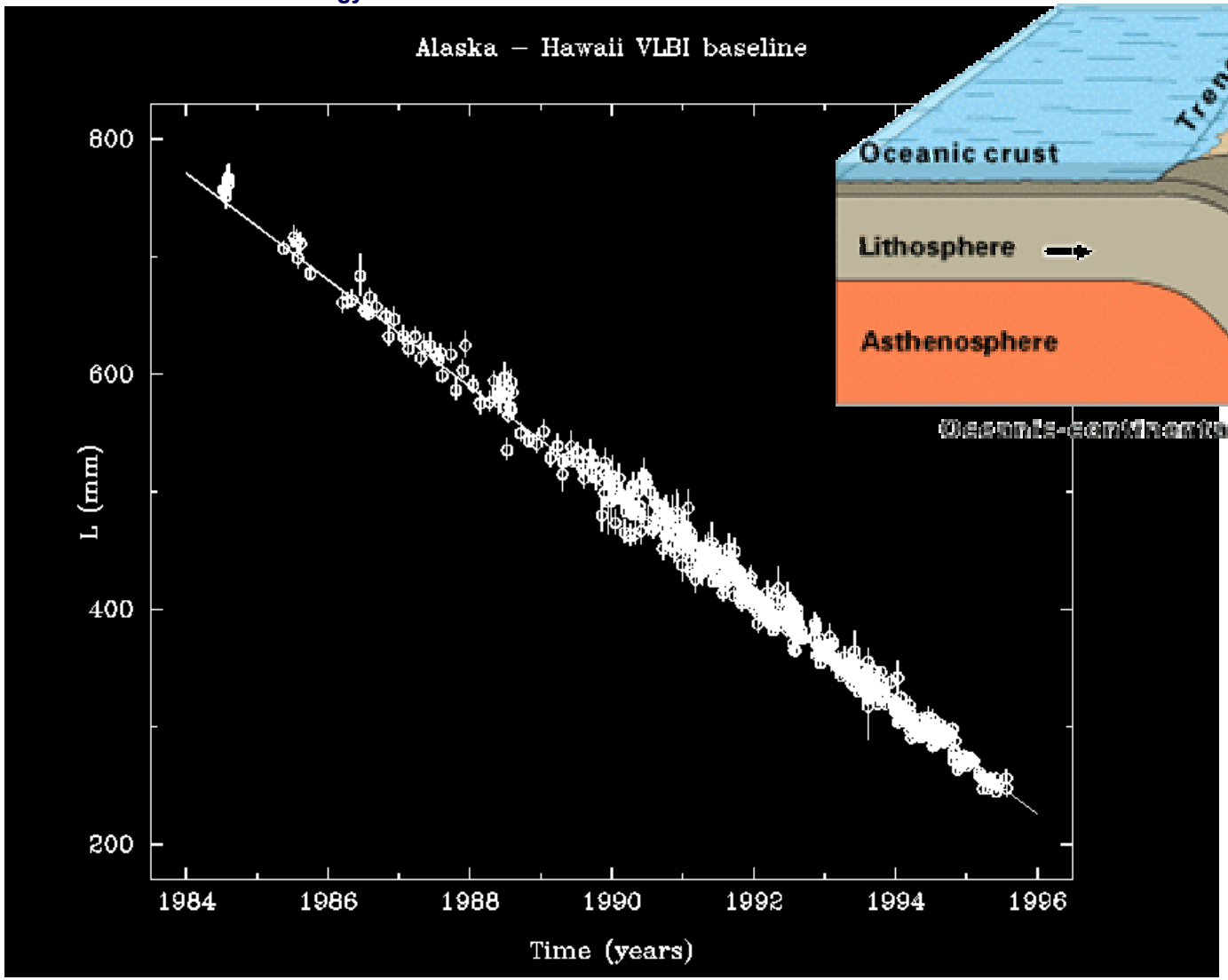

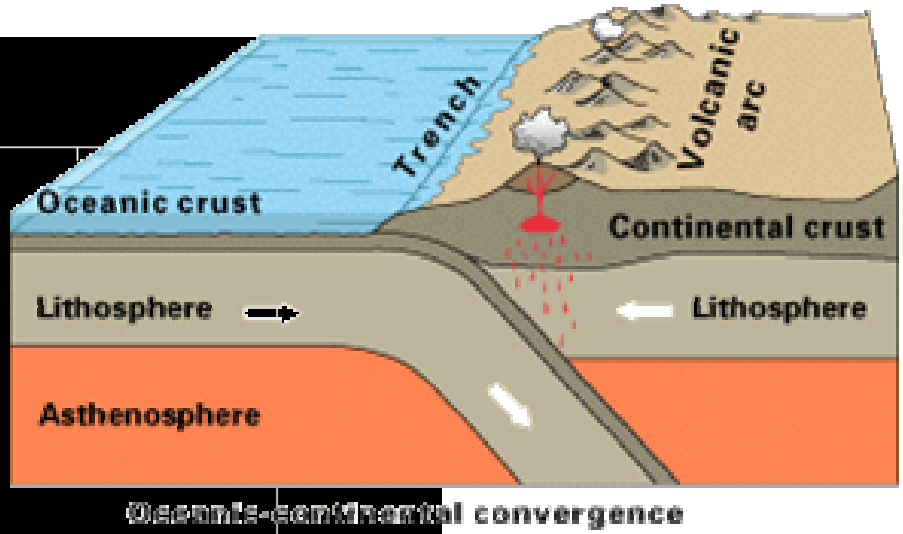

Tectonic Motion Calibrations

e.g. Alaska -Hawaii

-46 mm/yr

7 mm scatter

Credit Sovers, Fanselow, Jacobs, Rev Mod Phys 70, 4, Oct 1998.

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Goldstone:
(Apollo site)

DSS 24
DSS 25*
DSS 26*

Canberra
DSS 34

Madrid
DSS 54
DSS 55

***=large Δ from ground survey**

BWG Station Location Ties

Found and corrected ground survey Vertical

ERRORS:
0.5m DSS-25
0.7m DSS-26

Direct Radiometric (VLBI) Now gives ~ cm accuracy

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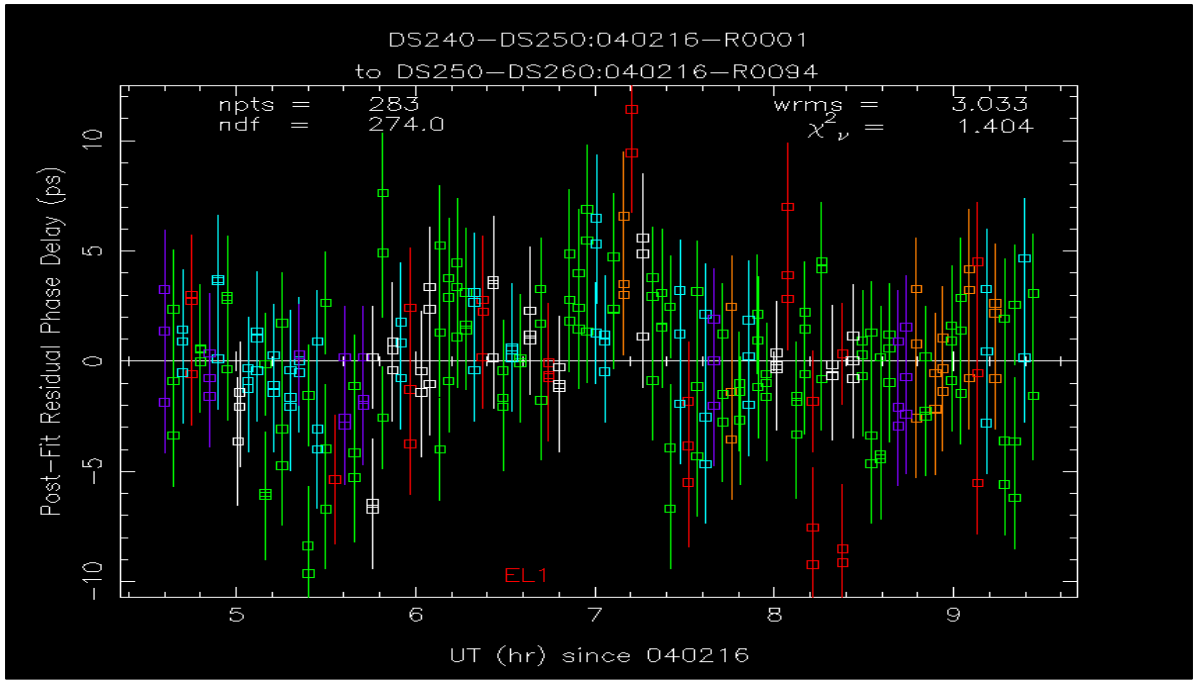
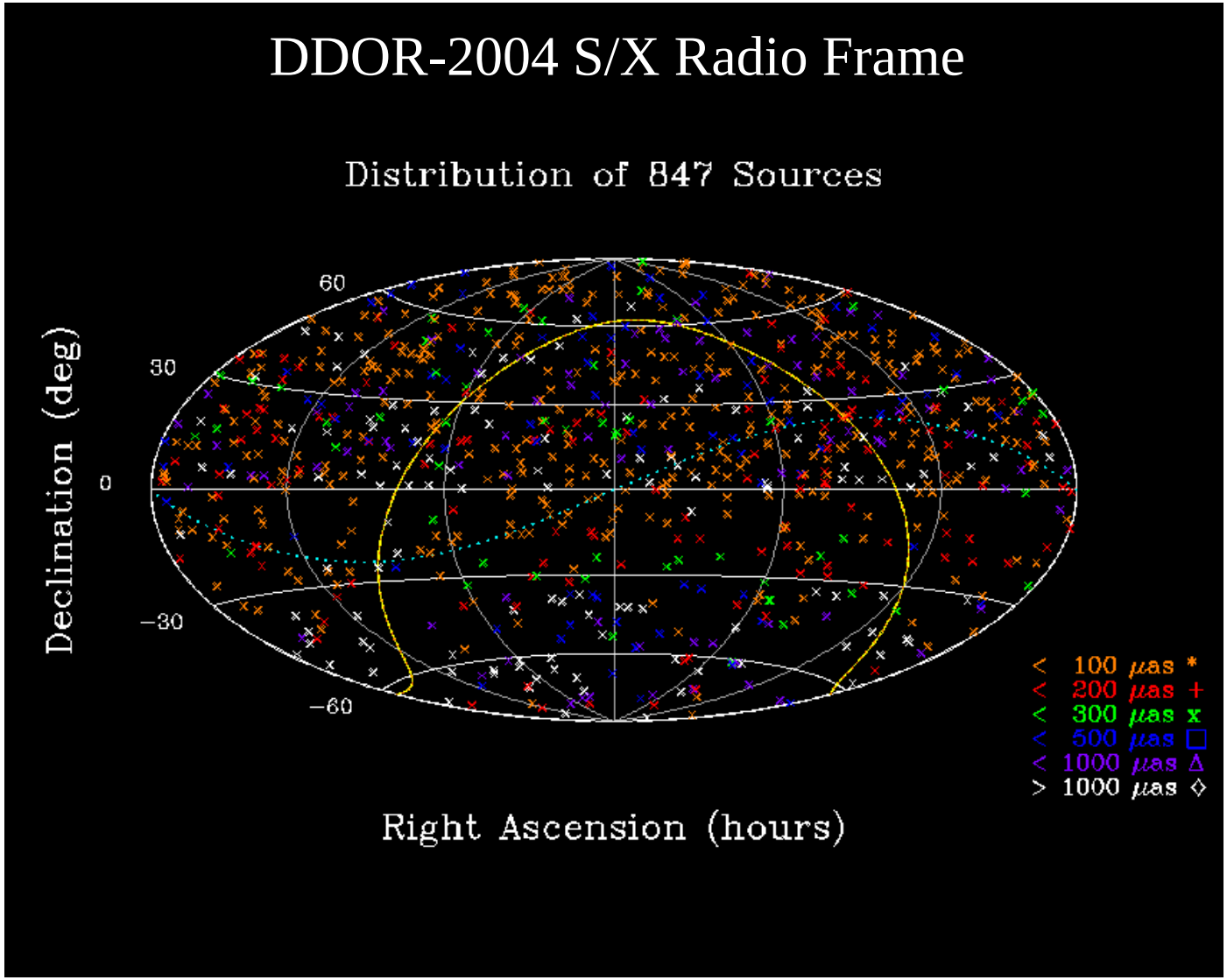
- Arrays are the future of the DSN
- VLBI software as it exists can array 34m BWGs
- We are using VLBI to study arraying.



Achieved goal of 1mm accuracy phase modelling using Apollo BWGs: 24,25,26


DDOR-2004 S/X Radio Frame
Distribution of 847 Sources
Declination (deg)
60
30
0
−30
−60
Right Ascension (hours)
< 100 μas *
< 200 μas +
< 300 μas x
< 500 μas □
< 1000 μas Δ
> 1000 μas ◇

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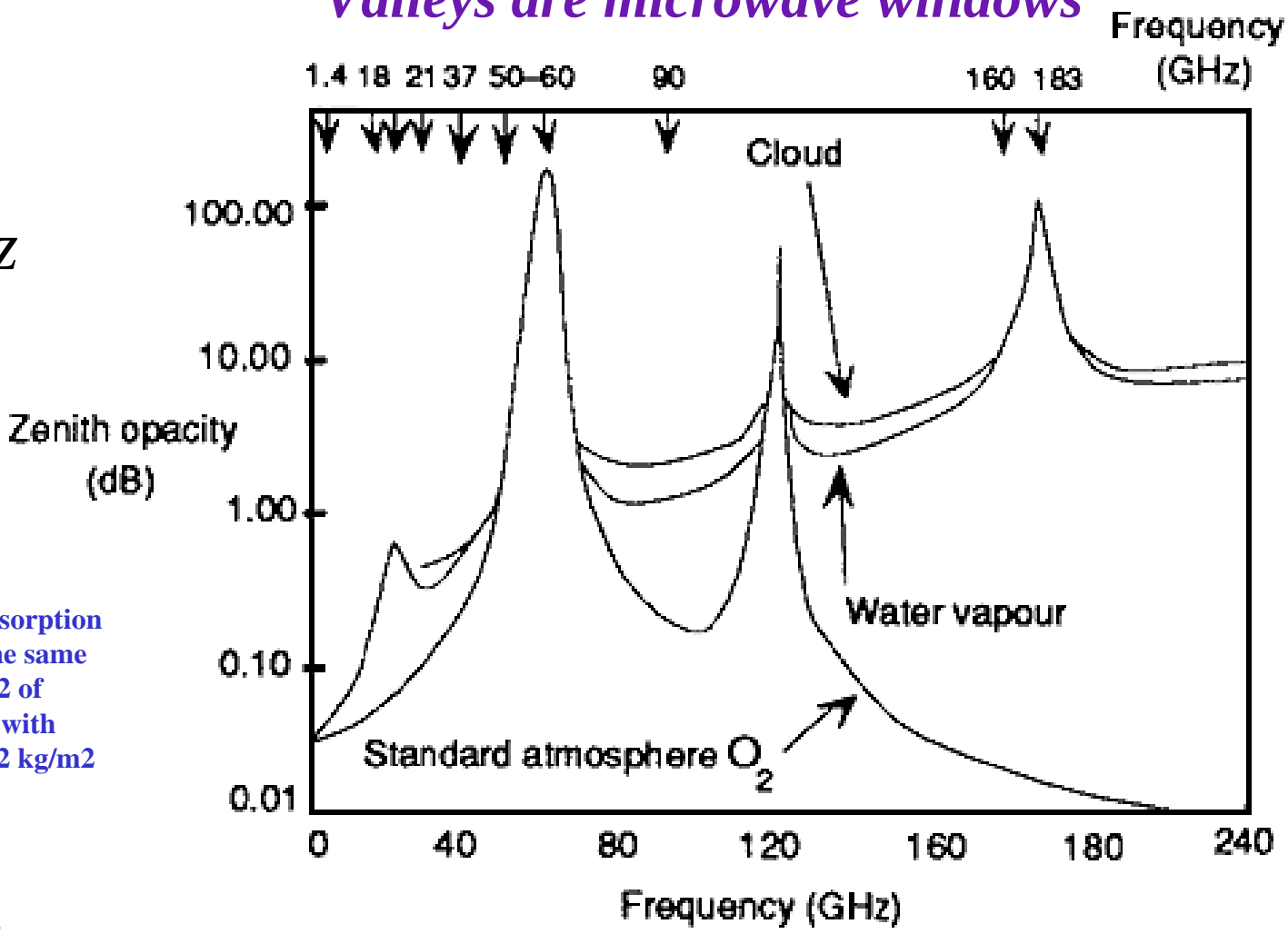
Valleys are microwave windows

Ka-band
= 32 GHz



The three curves show absorption in a dry atmosphere, in the same atmosphere with 20 kg/m2 of added water vapour, and with both water vapour and 0.2 kg/m2 of stratus cloud added.

Murphy, R. et al., 1987,
Earth Observing System Volume IIe:
HMRR High-Resolution
Multifrequency Microwave Radiometer.
Published by NASA, Goddard Space Flight Centre,
Greenbelt, Maryland 20771, USA, 59pp.

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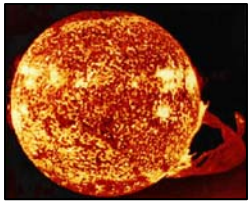
The FUTURE:

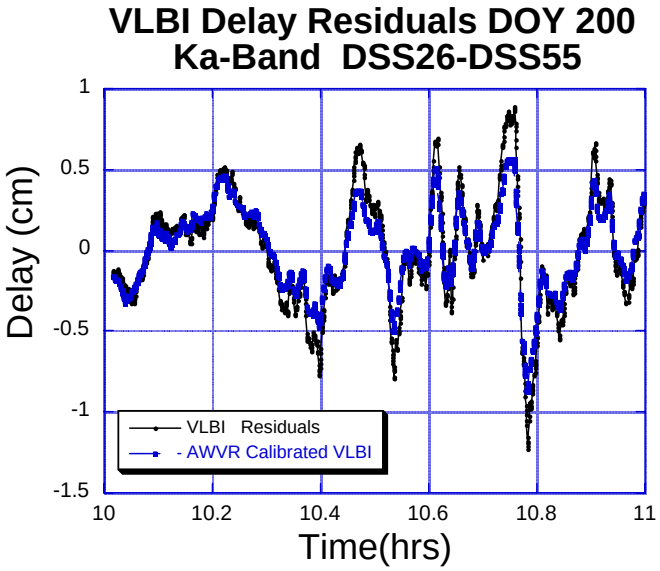
- **Ka-band (32 GHz) compare**
  X-band (8.4 GHz):
  - 15 times less
  sensitive to plasma



  - 4 times sharper focus on reference points
  - 5-10 dB higher telemetry rates

- **Water Vapor radiometers**
  - measure strength of 22 GHz water line
  - corrects for atmospheric turbulence
  - increases value of DSN data

- **Accuracy to 1 part in 10 billion?**
  This would be ~15 meters at Mars.



Picture credits: 1) SOHO/ESA/NASA,
2) Naudet et al, TMO Progress Report 42-143, 15 Nov 2000
tmo.jpl.nasa.gov/tmo/progress_report/42-143/title.htm

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We collaborate to use non-DSN resources Whenever possible!

We currently use the VLBA at S/X, K & Q.

We are working to get X/Ka-band in the VLBA array to lower load on DSN!

We also collaborate with the European VLBI Net.

(photos credit NRAO/NSF/AUI http://www.aoc.nrao.edu/vlba/html/vlbahome/thesites.html)

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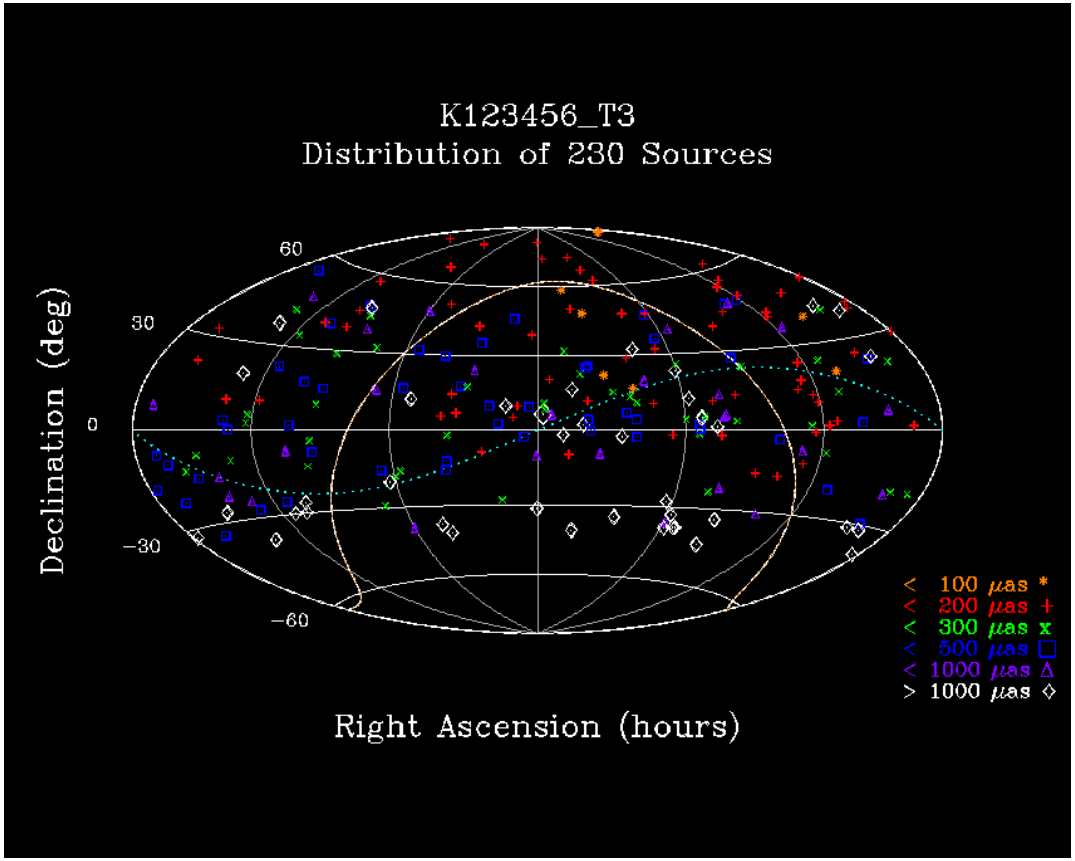
Some questions about Ka-band can be answered Using data from the VLBA at nearby K-band 24 GHz.

Thus we use DSN Ka-band time only for what cannot be done elsewhere.

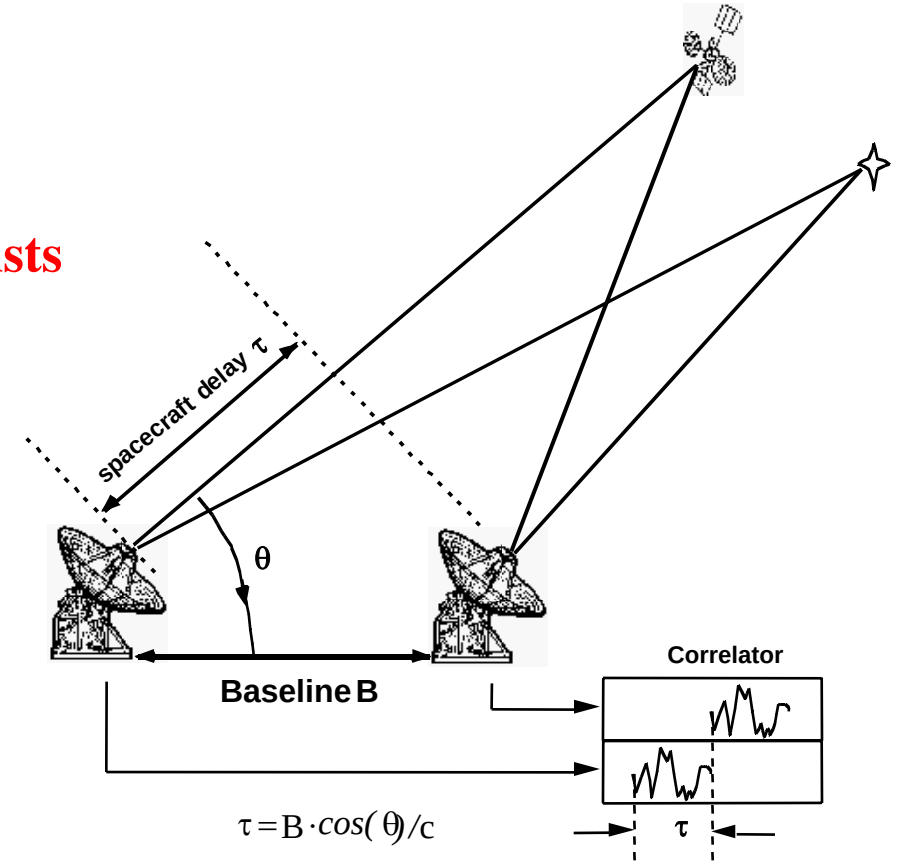
For example, the DSN has the world's only dual Band X/Ka Antennas which can calibrate plasma effects.



Credit: Jacobs et al, Proceedings of IVS General Meeting, Ottawa, Canada, Feb 8-12, 2004,
http://ivscc.gsfc.nasa.gov/meetings/gm2004/presentations.html

VLBI scheduling requirements:

- **Two stations at a time are needed because the VLBI signal doesn't exists until two stations are combined!**
- **Two complimetary baselines are needed within 6 weeks (CA-Aust, CA-Spain)**
- **We no longer need back to back baselines within a few days!**

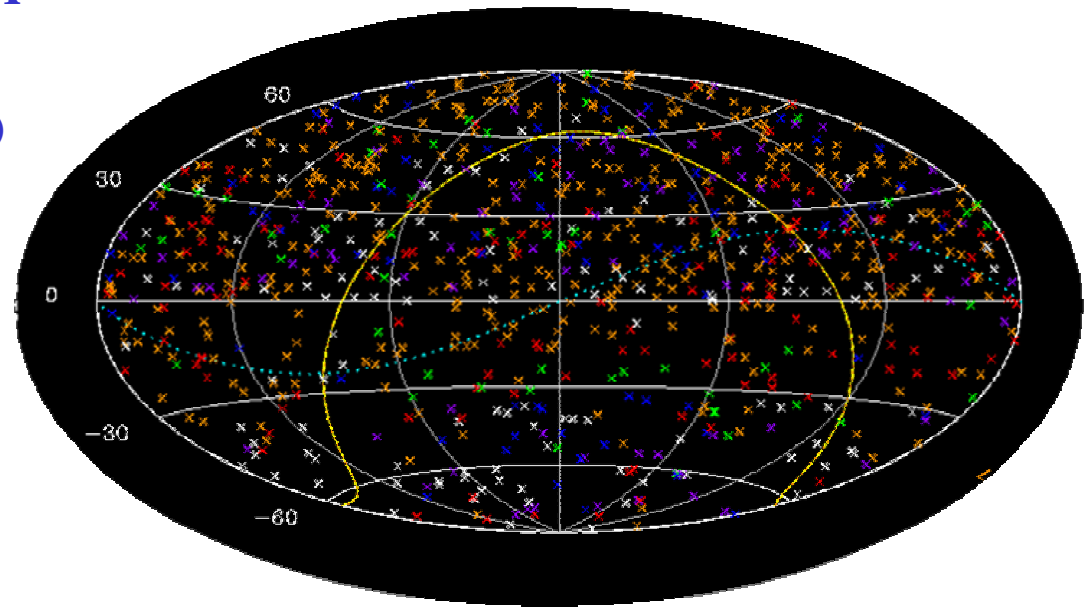


VLBI scheduling requirements:

- 24 hour duration
  We must cover full range of RA

- We must measure daily (24hr) signatures in data:
  - pole direction
  - tides
  - atmosphere

- Two 12 hour passes do NOT meet our requirements.



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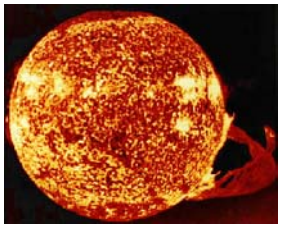
Scheduling Requirements: S/X and X/Ka



- S/X is still the standard for DSN navigation
  X/Ka demo for MRO '05; mainstream in few years

- S/X uses 34m HEFs

- X/Ka uses 34m BWGs

- We need a period of overlap with
- BOTH S/X and X/Ka.
- This may need to last for 5 or more years.

- **VLBI technique**

  Measures natural radio source (quasar) at edge of universe

  - measures angles on the sky
  - one part in a billion accuracy

- **Benefits to Navigation**

  ΔDOR => plane-of-sky positions

  Mars Ephemeris/Frame Tie

  Earth Orientation, Nutation

  Station locations - e.g. BWG ties

  Phase Models for next generation DSN array

- **Scheduling Requirements**

  Two or more stations

  24 hours to cover sky, measure signatures

  S/X on HEFs, X/Ka on BWGs

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Resource Allocation Review
2006 - 2008
TIMELINE FOR NEXT REVIEW
August 9, 2005

Calendar Date	Milestones
April 26, 2005	Distribute Mission Set, Major Events and User Loading Profiles to Projects/Users for verification.
May 20, 2005	Deadline for Projects/User's responses to Mission Set, Major Events, and User's Loading Profiles; and last day for trajectory or viewperiod updates or submissions.
July 14, 2005	NASA Headquarters Science Review
July 16, 2005	Publish preliminary Contentions and Recommendations on the RAPWEB for Projects/User's review.
August 1, 2005	Complete the review of RAPWEB published contentions with Projects/Users
August 9, 2005	**RESOURCE ALLOCATION REVIEW BOARD**